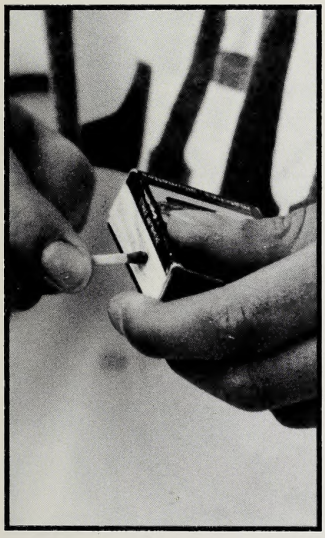
SCIENCE 9



Module 3

Heat Energy: Transfer and Conservation

Distance Learning

Alberta EDUCATION

Science 9

Module 3

HEAT ENERGY: TRANSFER AND CONSERVATION

Distance Learning

Alberta EDUCATION

Science 9
Student Module
Module 3
Heat Energy: Transfer and Conservation
Alberta Distance Learning Centre
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Welcome to Module 3!

We hope you'll enjoy your study of Heat Energy: Transfer and Conservation.
To make your learning a bit easier, a teacher will help guide you through the material.

So whenever you see this icon,

turn on your audiocassette and listen.

Contents

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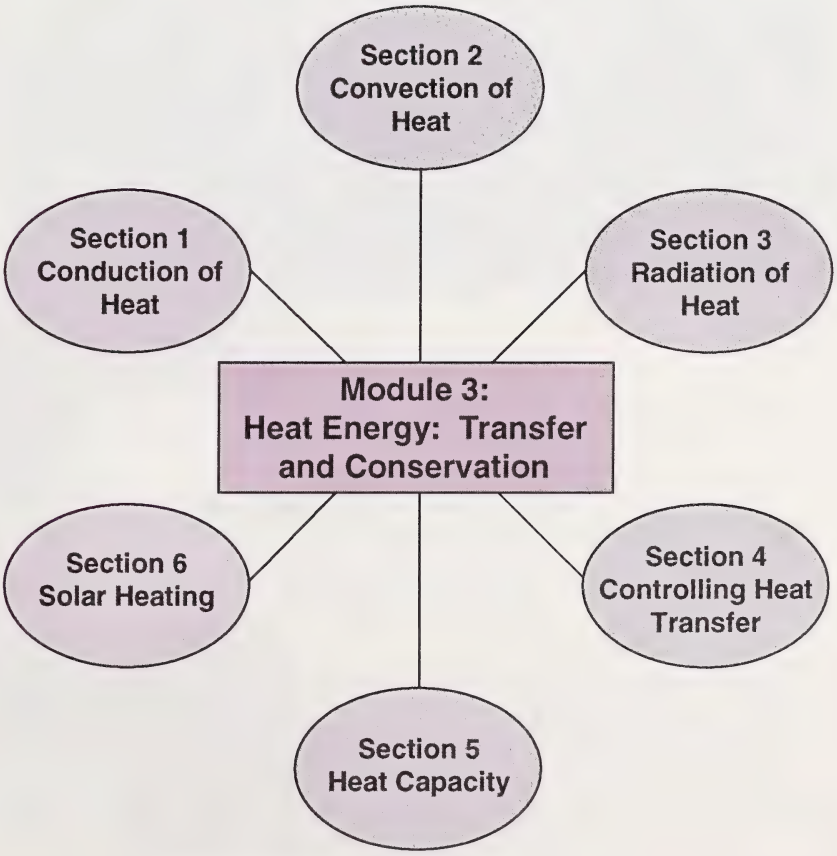
OVERVIEW

Do you remember those days last summer when you were trying to cool off? How about those cold winter days when all you wanted to do was stay cozy inside your nice warm house? You were actually trying to control heat transfer so that you could feel more comfortable.

Read page 118 in your textbook. Look at the pictures on pages 118 and 119. These pages offer some examples of the different methods of controlling heat transfer.

This module is designed to help you learn how to use technology to control the flow of heat energy. You will begin by looking at the three ways that heat can be transferred. This information will help you construct and test devices that control the transfer of heat. You will see that different substances have different warming rates. Finally, you will apply the technology of solar heating when you design and construct a model of a solar home.



Evaluation

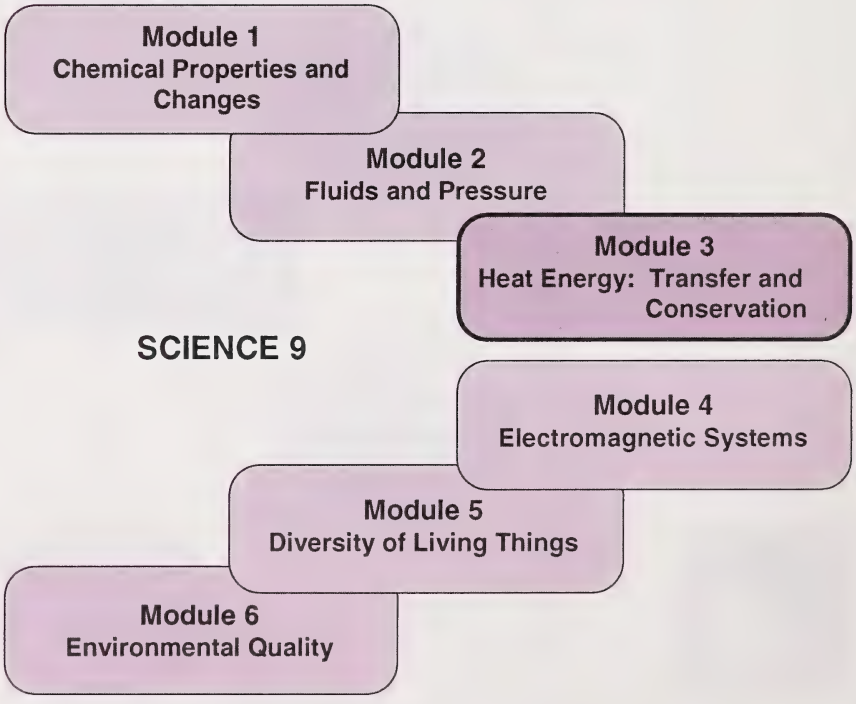
Your mark in this module will be determined by your work in the Assignment Booklet. You must complete all assignments. In this module you are expected to complete six section assignments.

The assignment breakdown is as follows:

Section 1 Assignment	**10%**
Section 2 Assignment	**10%**
Section 3 Assignment	**10%**
Section 4 Assignment	**25%**
Section 5 Assignment	**20%**
Section 6 Assignment	**25%**
TOTAL	**100%**

Course Overview

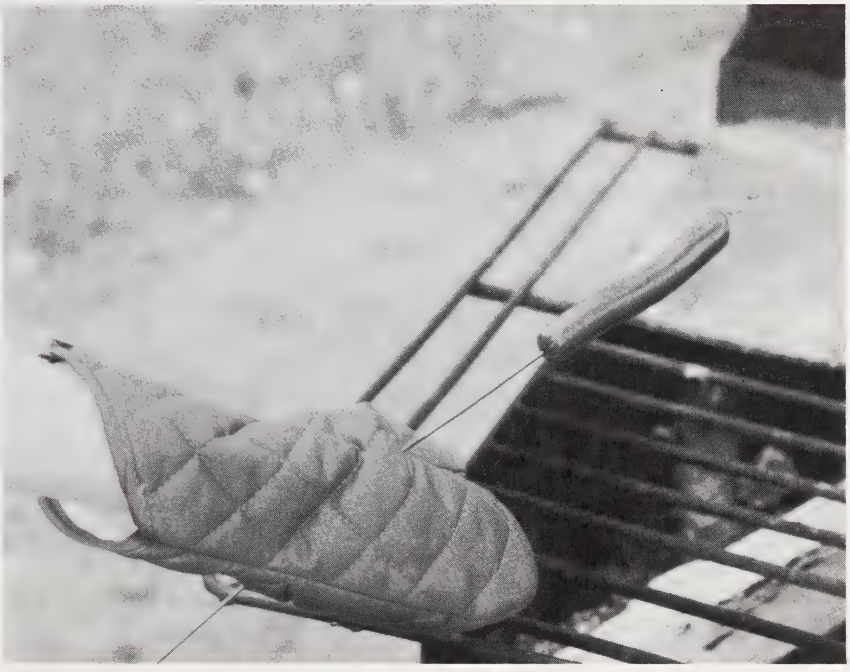
Science 9 contains six modules. The module you will be working on is highlighted.



Section

1

Conduction of Heat



Have you ever used a straightened coat-hanger to roast hot dogs or marshmallows in a fire? If you leave the food in the flames long enough, even the end that you are holding starts to feel hot! How do you think the heat from the fire gets all the way to the other end of the wire?

In this section you will learn about conduction, one of the ways that heat can move. After investigating whether all solids conduct heat equally, an explanation of how heat is conducted through materials will be developed. You will discover the difference between heat and temperature, and you will determine water's ability to conduct heat. You will also examine some of the ways that people have used their knowledge of conduction to solve practical problems.

Activity 1: Comparing Heat Transfer in Solids

It is wise to use oven mitts when removing a hot pot from the stove.

You may also have discovered that some laboratory equipment gets hot during use with a Bunsen burner or hotplate.

Read page 120 in your textbook and examine the drawing. Then answer the following question.

1. Which material allows heat to be transferred through it most easily, wood or metal? How can you tell from the drawing of the boy and girl?

_____

_____

_____

_____

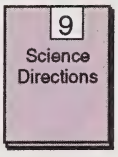
_____

Check your answers by turning to the Appendix, Section 1: Activity 1.

Do either Part A or Part B.

If you have the materials for Activity 3-1 on pages 121 and 122 of your textbook, do Part A. Otherwise, do Part B.

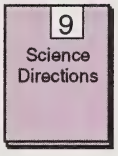
Part A



Review Handling a Heat Source and Rules for Using an Open Flame on pages xiii and xiv at the beginning of your textbook.

Caution: You will be using an open flame. Always wear safety glasses or other eye protection when using a heat source.

Investigation



Refer to Activity 3-1 on pages 121 and 122 of your textbook.

2. What is the problem for this investigation?

_____

_____

- Read step 1 of the procedure.

3. Rank the list of materials as directed.

_____ fastest

_____

_____

_____

_____ slowest

- Collect the materials required for this activity.
- Complete step 2 of the procedure.

4. The beads of wax all melted on the rod made of _____ and there were _____ beads of wax left on the other rod; therefore, the rod made of _____ was the better conductor of heat.

Conductometer: a device used to demonstrate the rate at which heat is conducted by several metal rods

You will now use a **conductometer** to test the ability of different metals to conduct heat. Check with your learning facilitator to determine the names of the metals you will test. Write the names of the metals in the chart provided after question 5.

- Do step 3 of the procedure.

Note: If you are using a candle as a heat source, instead of a Bunsen burner, place the wax beads at the midpoint of each rod, rather than at the end.

5. Record the melting times for the wax beads on each rod.

Metal	Time for Wax to Melt (in seconds)

Extinguish your flame and allow your equipment to cool completely before putting it away.

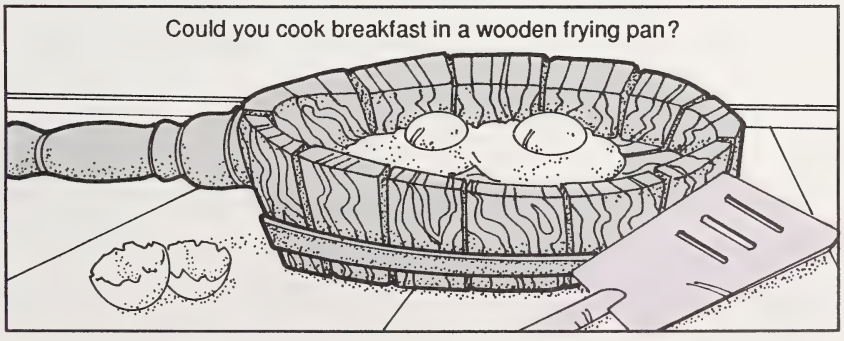
End of Part A

Part B

Read the following paragraph. Then answer questions 6 and 7.

Last winter Sarah observed frost on the metal frames around the windows of her cabin. In colder weather, frost formed on the glass as well. On the other hand, there was never any frost on the wooden walls.

6. Based on these observations, what inferences can you make about the abilities of metal, glass, and wood to conduct heat?



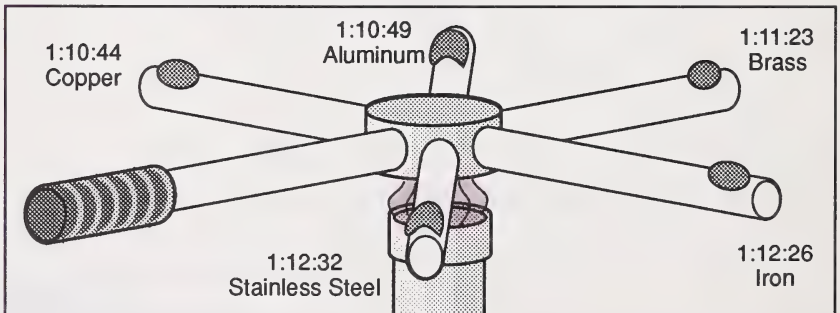
7. Describe an experiment that could be used to test your inferences. Be sure to include how you would control the variables, such as the thicknesses of the materials being tested.

Investigation

9 Science Directions

Refer to Activity 3-1 on pages 121 and 122 of your textbook. Read step 3 of the procedure.

Several students in a Grade 9 class conducted the investigations in Activity 3-1 using a conductometer similar to the one shown in the diagram. The students used a digital watch to record the time it took for the wax beads to melt on each of the rods. These times are recorded in the diagram.



8. Use the information from the preceding diagram to fill in the following chart.

Metal	Time for Wax to Melt (in seconds)

End of Part B

9. Do question 2 of Analysis on page 122 of your textbook.

_____ fastest

_____

_____

_____

_____ slowest

10. Do question 4 of Further Analysis.

_____

_____

_____

_____

_____

_____

Check your answers with your learning facilitator.

Activity 2: Heat and Temperature

Is it cold out today? What is the temperature? In most cases you probably use the words *heat* and *temperature* to mean approximately the same thing, but they actually do not mean the same thing. You are about to find out how heat and temperature are different.

Read pages 122 and 123 in your textbook. Then answer the following questions.

1. Look at the weather map in the picture at the top of page 122. The numbers recorded on the map are used to describe how hot or cold the air is at various locations.

   a. What do we call these measurements?

   _____

   b. What instrument is used to measure how hot or cold a substance is?

   _____

The particle theory states that all substances, including air, are made of very small particles.

2. How does the motion of cold particles differ from the motion of hot particles?

   _____

3. Why will individual particles of a substance be moving at different speeds instead of all moving at the same speed?

_____

_____

4. The _____ (speed, size, colour) of a particle indicates its _____ (heat, energy) level.

5. Temperature measures the _____ (average, total) speed of many particles, or their _____ (average, total) energy level.

9 Science Directions

Read the three definitions at the top of page 123.

6. In your own words, what is the definition of *temperature*?

_____

_____

_____

7. In your own words, what is the definition of *heat*?

_____

_____

_____

9 Science Directions

The comic strips on page 123 should help you understand how heat and temperature are related to particle motion.

8. What do the little yellow characters in the first comic strip represent?

_____

9. Do all four yellow particles move at the same speed? Explain your answer.

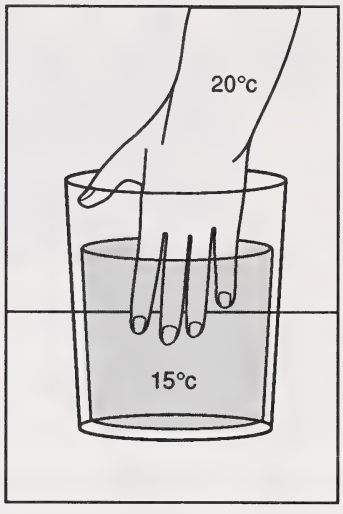
_____

_____

10. Why is the temperature the same whether there are four or eight yellow particles?

_____

Use what you have learned from the comic strip to answer the following questions.



11. a. Would water that is 15°C feel warm or cold to your hand if your skin temperature is 20°C?

_____

b. Does heat move from your hand to the water, or from the water to your hand?

_____

12. If an ice cube is dropped into a cup of coffee, would heat be transferred from the ice to the coffee or from the coffee to the ice?

_____

Check your answers with your learning facilitator.

Activity 3: How Heat Is Conducted

As you have experienced many times, heat can move from one substance to another. When you heated the metal rods you found that they conducted heat at different rates. How does heat travel through solids?

Read page 124 in your textbook. Then answer the following questions.

1. Describe the conduction of heat through a metal rod that is being heated at one end. Be sure to explain what the particles are doing.

_____

_____

_____

_____

2. What term describes substances, such as metals, that readily allow heat to transfer through them?

_____

Check your answers by turning to the Appendix; Section 1: Activity 3.

Investigation

Refer to Activity 3-2 on page 125 of your textbook.

3. What is the problem for this investigation?

_____

_____

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Science
Directions

4. Read step 1 of the procedure and make your prediction.

_____

_____

9 Science Directions

Review the sections called Handling a Heat Source and Rules for Using an Open Flame on pages xiii and xiv at the beginning of your textbook.

Caution: Any open flame is hazardous! Always wear safety glasses or other eye protection when using a heat source.

- Collect the materials required for this activity.

Note: A hand-held test tube holder or tongs may be used in place of the support stand and clamp shown in your textbook.

- Do step 2 of the procedure.

5. Record your data in the following chart.

Heat Conduction in Liquids

Time (minutes)	1	2	3	4	5	6	7	8	9	10
Temperature (°C)										

6. Compare your results with your prediction and then answer question 1 of Analysis.

_____

7. Think about how heat is conducted through a solid and then answer question 2 of Analysis.

_____

_____

_____

8. Keeping in mind that a substance that is a non-conductor would not transfer any heat, answer question 3 of Analysis.

_____

_____

_____

9. Consider the spacing of particles when you answer question 5 of Further Analysis.

_____

_____

_____

You have tested solids and found that they have different abilities to conduct heat. A similar test was performed on water. Any substances can be tested to see how well they conduct heat.

Read Thermal Conductivity on page 126 in your textbook. Then use Table 3-1 on page 126 to answer the following questions.

10. In the last question of the investigation you just completed, you made a prediction about the conductivity of gases. Were you correct? Explain your answer.

_____

_____

_____

11. Arrange the following items in proper order from greatest to least thermal conductivity: brick, air, copper, and water.

_____ greatest

_____

_____

_____ least

12. The substance from Table 3-1 through which heat is most easily transferred is _____. Its thermal conductivity is rated as _____ compared to air.

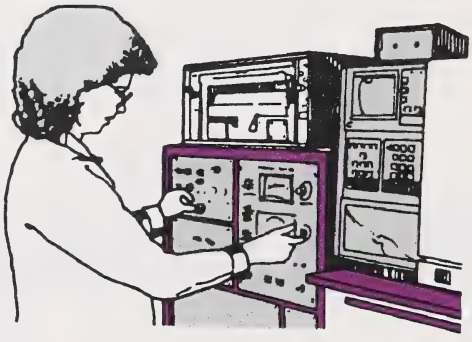
Check your answers with your learning facilitator.

Activity 4: Applications of Heat Conduction

Heat conductor: *a material that allows heat to transfer through it easily*

Heat insulator: *a material that helps to prevent the transfer of heat*

The thermal conductivities of many substances have been measured by scientists and engineers. This information can be used to select the best material for a **heat conductor** or a **heat insulator**.



Read Applications of Heat Conduction on pages 126 and 127 of your textbook.

1. If human skin and tissues were very good heat conductors, it would be dangerous to leave heating pads or cold packs on your body for very long. Explain why.

_____

_____

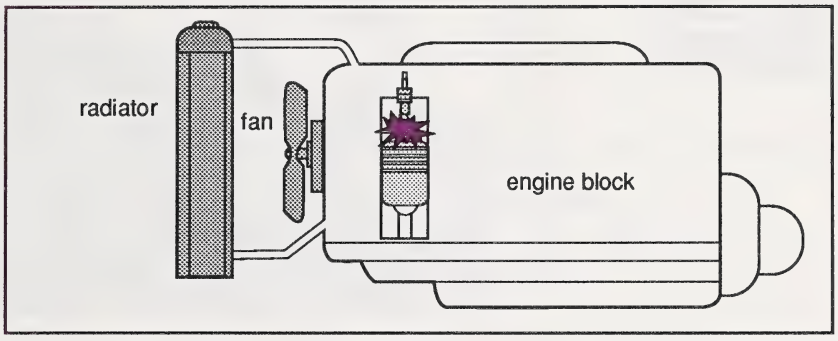
_____

_____

_____

_____

2. Put arrows on the following diagram to show the path that heat takes in the cooling system of an automobile. Begin where the explosion of the fuel in the engine converts chemical energy into heat and motion. Circle two places where conduction occurs.



3. What metal would be a poor choice for the material from which to make an automotive radiator? Give your reason.

_____

_____

_____

Check your answers by turning to the Appendix, Section 1: Activity 4.

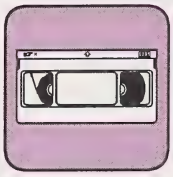
Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

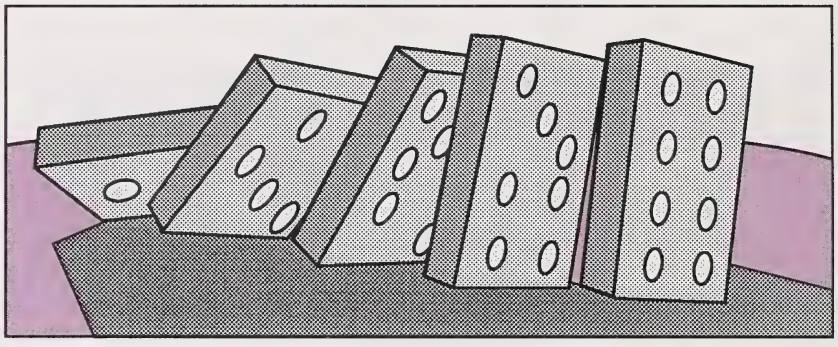
Do either Part A or Part B, or both.

Do Part A if you have a VCR and the videotape *Eureka: Conduction*. Otherwise, do Part B.



Part A

View the videotape *Eureka: Conduction.*



1. Explain how the behavior of the dominoes shown in the video demonstrates conduction?

2. What must a material do in order to be called a good conductor?

3. Why are metals such good conductors?

Check your answers by turning to the Appendix, Section 1: Extra Help.

Part B

4. Use the words from the following list to correctly fill in the blanks in the paragraphs. Each word will be used once.

vibrate	quickly
less	conduction
transferred	energy

Knowing how heat moves from one place to another helps you control heat. One way that heat can be transferred from place to place is by _____. Conduction happens when a moving particle with lots of energy collides with a slower particle with _____ energy. Bumping into the slower particle transfers _____. This speeds up the motion of the slower particle.

Imagine two people walking down the street towards each other and bumping into each other. They are both going to get a little shaken up. Now imagine that one of them is running. If they collide, a lot of energy is going to be transferred!

Particles of matter behave in a similar fashion. A hot particle which has picked up heat energy from a heat source such as a flame begins to vibrate very _____. When it collides with another particle, some energy will be _____. The second particle will start to _____ more quickly too. You can see this illustrated in the diagram at the bottom of page 124 in the textbook.

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Science Directions

5. In the space below, draw and colour a picture that is similar to the one on page 124 in the textbook. Your picture should show the particles vibrating in the solid rod. It should also show how energy (heat) is passed from one particle to the next. Colour your flame red to show lots of heat. The end of the rod that is in the flame should be red as well. Colour the middle of the rod orange to show that it is heated up a bit. The end farthest from the flame should be coloured black to show that it is still cool.

6. In your own words, explain how the heat would travel along the rod in your drawing.

Check your answers by turning to the Appendix, Section 1: Extra Help.

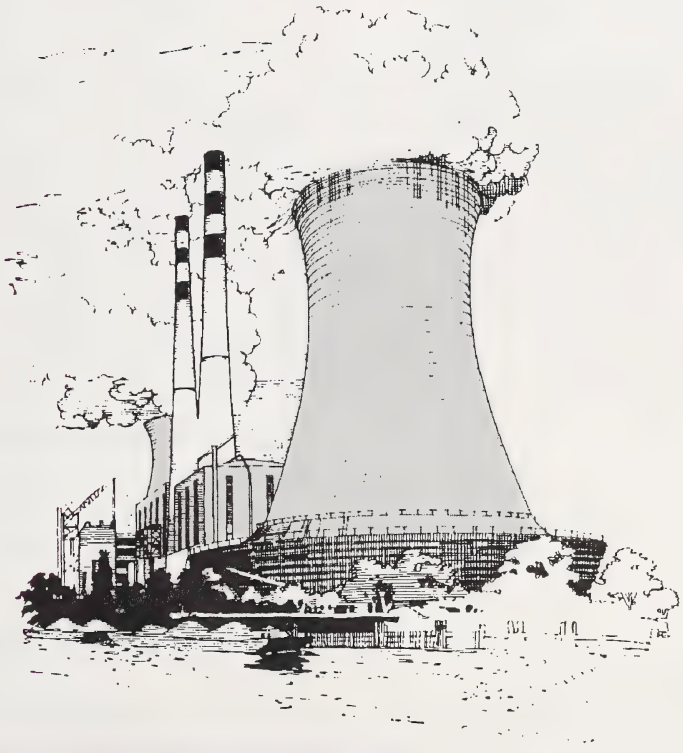
Enrichment

Do either Part A or Part B, or both.

Do Part A if you like to figure out inventive solutions to problems. Otherwise, do Part B.

Part A

Sometimes the ability to control conduction of heat can make a difference in a life-or-death situation. For instance, heat in a nuclear powerplant must be carefully controlled to ensure safe operation of the reactor. Serious accidents can occur when the reactor is not continually cooled.



Read Did You Know? on page 127 in your textbook.

1. Think of another situation where conduction of heat might prevent a fire or explosion, keep someone from burning themselves, or maybe provide heat to keep something from getting too cold. Come up with an invention to save the day in one of these situations. In the space provided, draw a simple diagram of your invention and give a brief explanation of the situation and how your device works.

Explanation: _____

_____

_____

_____

_____

_____

_____

_____

_____

Share your answers with your learning facilitator.

9 Science Directions

Part B

2. Do questions 5, 6, and 7 on page 135 of your textbook.

Textbook question 5. (a):

Textbook question 5. (b):

Textbook question 5. (c):

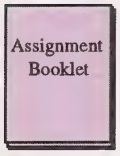
Textbook question 6:

Textbook question 7:

Check your answers by turning to the Appendix, Section 1: Enrichment.

Conclusion

In this section you have studied conduction, one of the ways that heat can move. You discovered that all solids do not conduct heat equally, and you learned how heat is conducted through different materials. The difference between heat and temperature was discussed and you did an investigation to show that water is not a very good conductor of heat. You also examined a number of ways that people have used their understanding of heat conduction to solve practical problems.



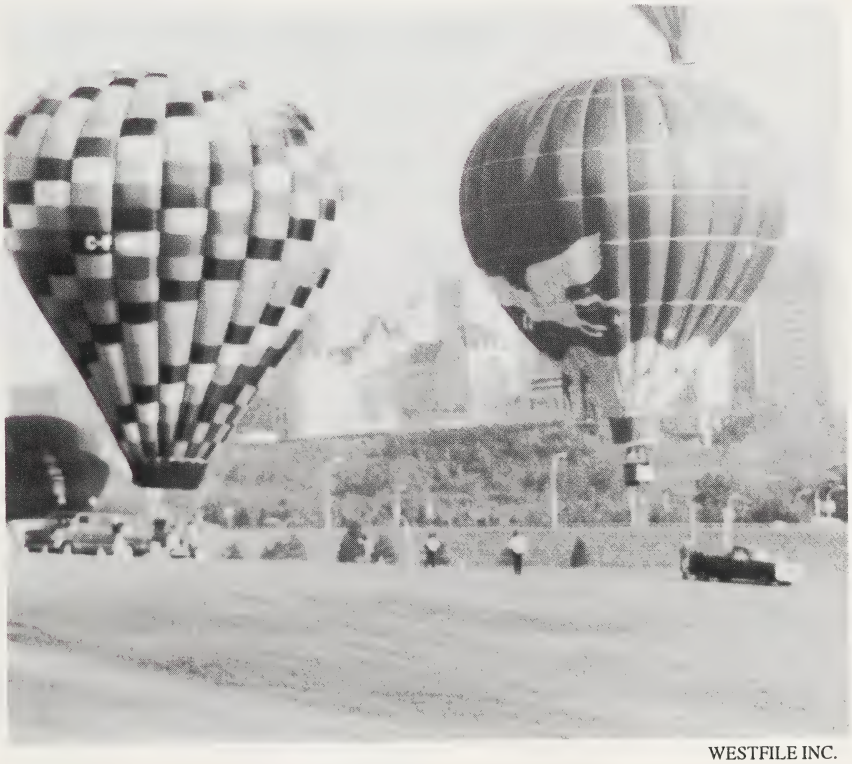
ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 1.

Section

2

Convection of Heat



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If a hot-air balloon is just a bag of air, how can it fly? Part of the explanation can be found by examining the principle of convection.

Convection is another way that heat can be transferred. By investigating convection in fluids you will discover the convection currents that exist in the natural world and be able to explain why they occur.

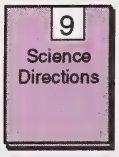
Activity 1: Observing Heat Transfer in Fluids

Convection: the transfer of heat by the circulating motion of a fluid

Convection can transfer heat in liquids and gases better than conduction.

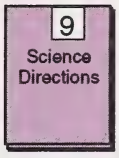
Read the paragraph at the top of page 128 in your textbook.

Investigation



Review Handling a Heat Source and Rules for Using an Open Flame on pages xiii and xiv at the beginning of your textbook.

Caution: You will be using an open flame. Always wear safety glasses or other eye protection when using a heat source.



Refer to Activity 3-4 on page 131 of your textbook.

1. What is the problem for this investigation?

_____

_____

_____

Do either Part A or Part B.

Do Part A if you are able to obtain the laboratory equipment required for doing Alternative B of this investigation as described in the textbook. Otherwise, do Part B.

Part A

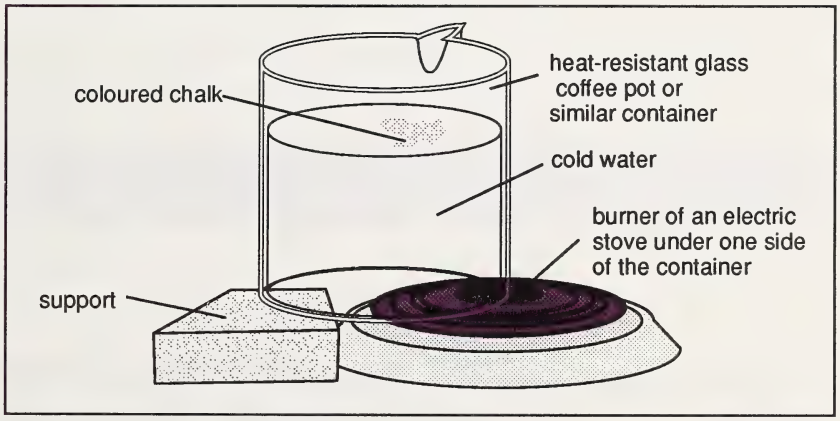
- Collect the materials required to complete Alternative B of Activity 3-4.
- Do steps 1 and 2 of Alternative B of the procedure.

This investigation requires care in setting up the apparatus. Place a small iron ring under the beaker and a large ring around the top of the beaker to hold it securely. A wire screen is not used under the beaker so that the heat will be focussed on one spot. Start with the heat source at a low setting. Use coloured chalk dust or coloured ice to make the motion of the water visible.

Part B

The following materials are needed:

- safety glasses
- heat-resistant (Pyrex™) coffee pot or similar container
- heat source such as a stove burner
- non-flammable support for the unheated side of the container
- coloured chalk dust or coloured ice
- cold water



- Set the heat-resistant container on a stove burner so that only one side is heated. Be sure to support the unheated side of the container so that it is very stable and will not tip.

- Continue with step 1 and step 2 of Alternative B in your textbook.

End of Part B

2. Describe the movement of the water directly above the heat source.

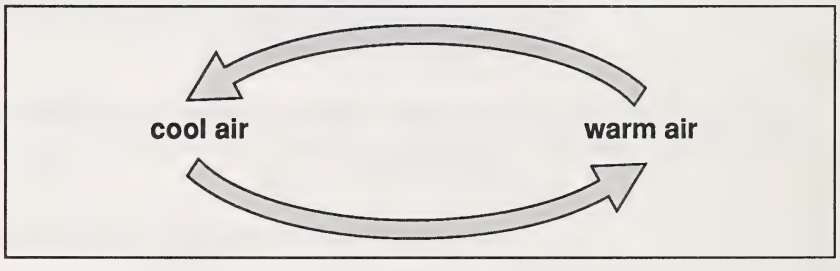
3. What do you see happening in the beaker to indicate that there is not only upward movement in the water?

4. Give an example of something you have observed elsewhere that makes you think that the type of movement you have seen in water can also occur in air.

Check your answers with your learning facilitator.

Activity 2: How Heat Is Transferred by Convection

Read page 132 in your textbook for an explanation of convection currents.



1. Using the particle theory of matter, describe and explain the movements you observed in the water in the previous investigation.

2. Why can convection not occur in a solid?

_____

_____

3. What is the main difference between conduction and convection?

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 2.

Activity 3: Convection in Nature

After investigating convection in fluids and developing an understanding of how it works, you may recognize some similar events in nature.

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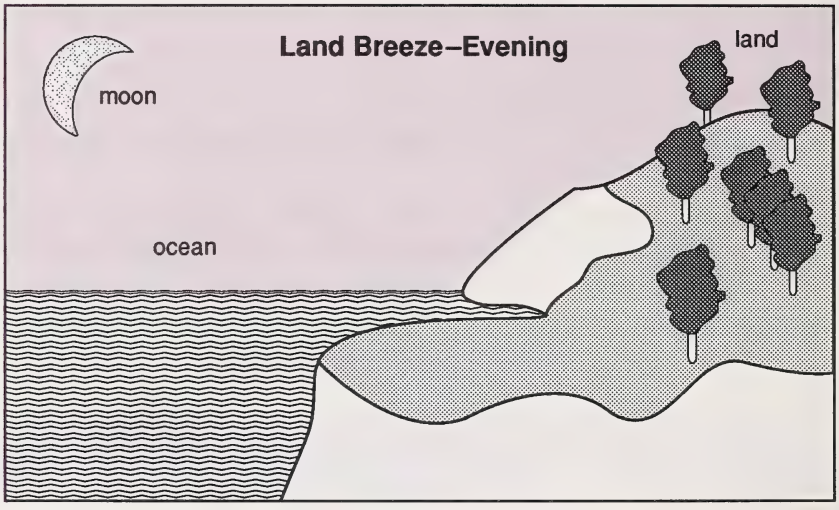
9 Science Directions

Read page 133 and 134 in your textbook.



1. On the preceding diagram, label the places where the warmest and coolest air would be found.

2. Draw arrows on the preceding diagram to show the movement of air in a complete convection current.

3. Describe another example of convection in nature, other than land and sea breezes, that is discussed in the textbook.

Check your answers with your learning facilitator.

Follow-up Activities

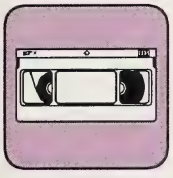
If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

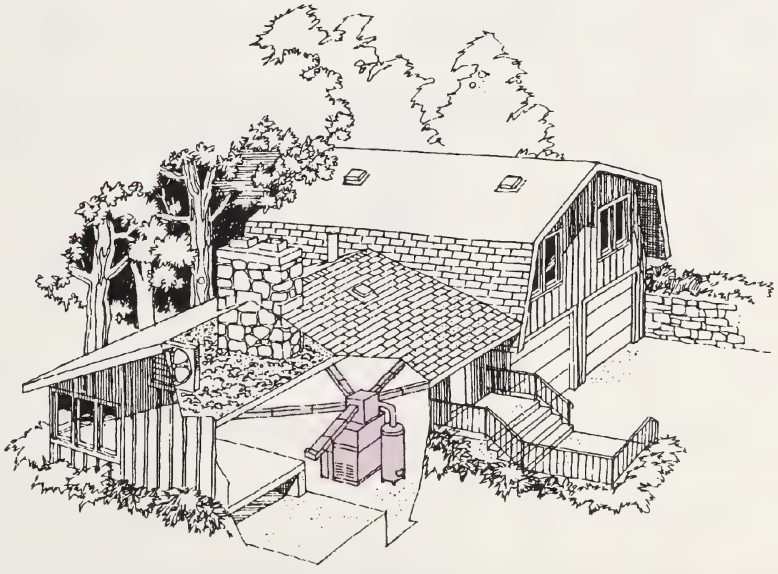
Do either Part A or Part B.

Do Part A if you have a VCR and the videotape *Eureka: Convection*. Otherwise, do Part B.

Part A

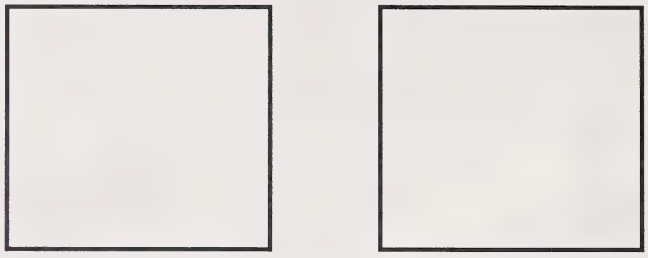


Watch the videotape *Eureka: Convection*.



1. In a home heating system, why is the furnace in the basement?

2. In the following boxes, draw circles to represent particles of matter. Show how the particles are spaced differently in hot and cold fluids.



3. What name is given to the tendency of less dense objects to float on top of more dense objects?

_____

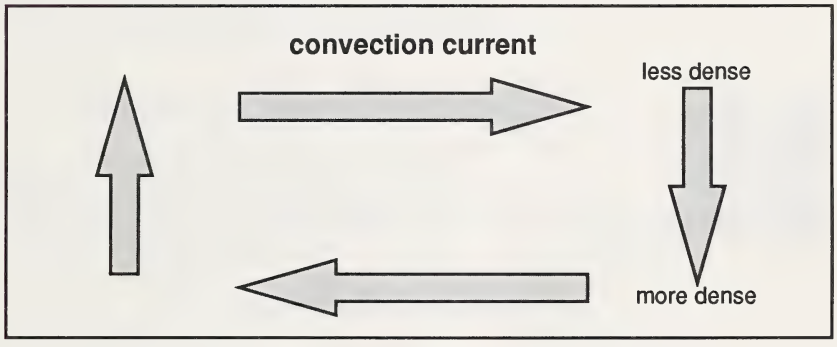
Part B

4. Use the words from the following list to correctly fill in the blanks in the following paragraphs. Each word will be used once.

energy	more
warmer	convection
solids	conduction
fluids	convection current

Conduction is a good way for heat to move in _____. In fluids _____ does not work very well. Instead, in both liquids and gases, _____ occurs. Because the particles of _____ are free to flow, they tend to move around, rather than vibrate in place and pass their energy to their neighbours. When a fluid gains _____, the particles near the heat source begin moving more rapidly and spread out as they collide more often, pushing each other away.

This makes the fluid less dense where the _____ particles are found. The less dense parts of the fluid tend to rise above the _____ dense parts. This rising of one part and falling of another sets up a _____ _____.



5. Why are the particles in a hot fluid farther apart than the particles in a cold fluid?

_____

_____

_____

6. If hot gas is released into a room, will it tend to go up or down?

_____

7. When you open the refrigerator door, does the cold air that escapes tend to rise or fall?

_____

Check your answers by turning to the Appendix, Section 2: Extra Help.

Enrichment

Do either Part A or Part B, or both.

Do Part A if you are working alone. Part B is only practical if several people can work together as a group and suitable equipment and materials can be obtained.

Part A

Read Probing on page 132 of the textbook.

1. Sketch out a plan for a house like the one described. You may wish to include vents, staircases, windows, and doors to influence the flow of air.

Share your answers with your learning facilitator.

9 Science Directions

9 Science Directions

Part B

For a review of the steps in making a graph, refer to page 356 of the textbook.

Investigation

Refer to Activity 3-3 on pages 129 and 130 of the textbook.

2. What is the problem for this investigation?

_____

_____

Refer to Alternative B in the procedure. Then gather the equipment and materials required for this activity. Do steps 1 to 5 of the procedure.

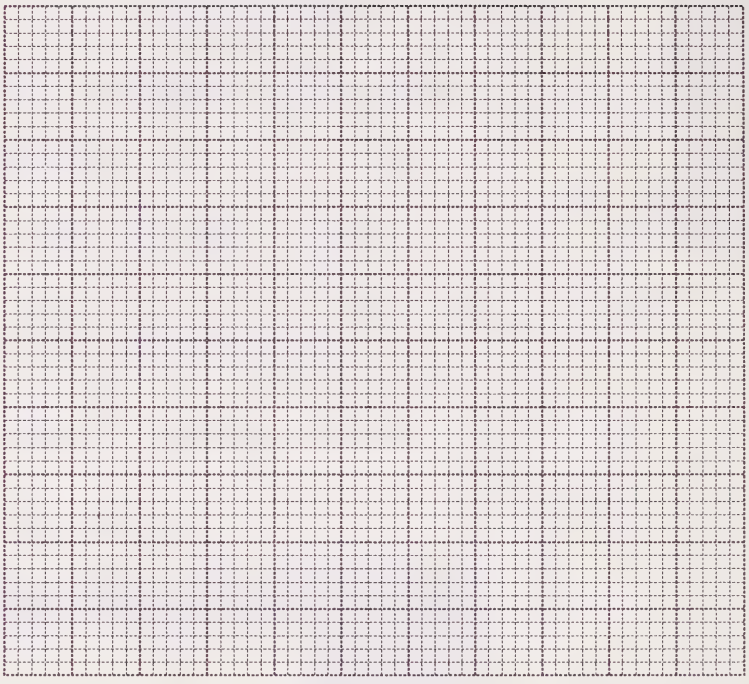
3. Record your observations in the following chart.

Heat Transfer in Air

Time (min)	0	1	2	3	4	5	6	7	8	9	10
Temp. #1 (°C)											
Temp. #2 (°C)											
Temp. #3 (°C)											
Temp. #4 (°C)											
Temp. #5 (°C)											

4. Do question 3 in Analysis.

Textbook question 3. (a):

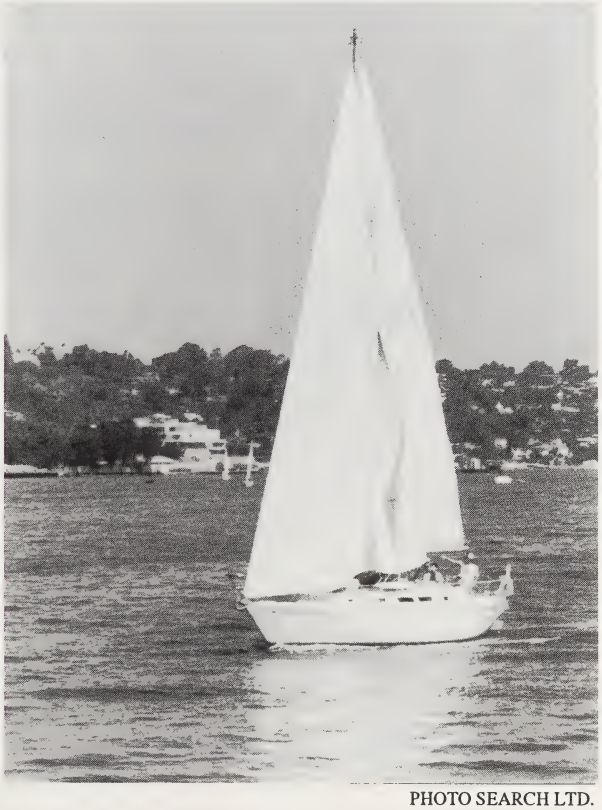


Textbook question 3. (b):

Discuss your answers with your learning facilitator.

Conclusion

In this section you studied convection, the method of heat transfer in fluids. Convection currents are described as the result of the difference in density between warm and cold areas in a fluid. You should now understand that particles in solids transfer heat from one particle to another by conduction, while particles in fluids are free to move and carry the energy with them by convection. Land and sea breezes, thermal updrafts, and formation of the earth's magnetic field are examples of convection in nature.



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Assignment Booklet

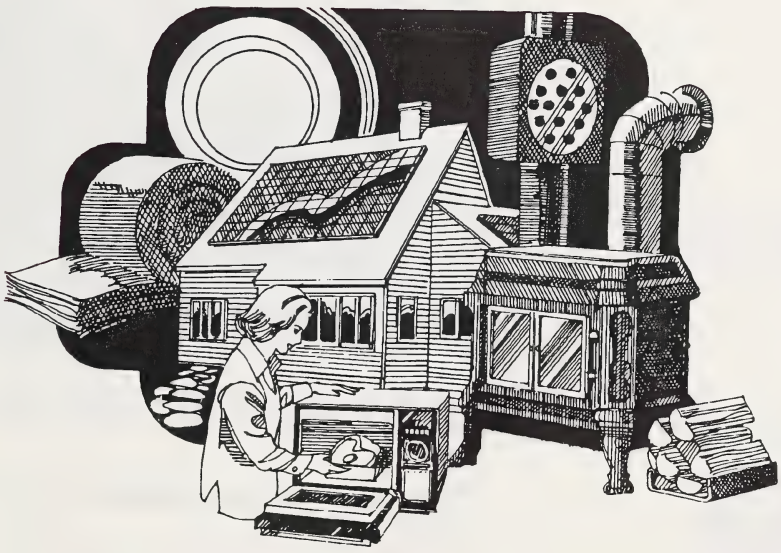
ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

3

Radiation of Heat



This person is surrounded by devices that work because energy can be transferred in a third way that you will now learn about. This third method of energy transfer is called radiation, or radiant energy. Radiant energy is commonly found in nature, but people have developed technologies to control and use this energy.

Studying the properties of radiant energy will help you understand how to use technology to control the radiation of heat.

Activity 1: The Effects of Radiant Energy

DAVE MORRIS

Radiant energy: energy transmitted by means of radiation

9 Science Directions

Technology can produce **radiant energy** that duplicates the types found in nature.

To learn more about the different types of radiation, read page 136 of the textbook.

1. Name four different forms of radiant energy.

   _____

   _____

   _____

   _____

2. The complete range of forms of radiation can be called a _____.

3. Radiant energy is transmitted as waves. Different types of waves have different amounts of energy. The lowest energy waves in the spectrum are _____ waves and the highest energy waves are _____ rays. The most dangerous waves are the _____ energy waves.

4. As a method of heat transfer, how is radiation different from conduction and convection?

One important thing to understand about radiant energy is how it interacts with matter. When waves of energy strike matter they might bounce off, go straight through, or be absorbed. The properties of the matter being struck by the radiation determine what will happen.

Check your answers by turning to the Appendix, Section 3: Activity 1.

9 Science Directions

Before you continue with the following investigation, you should review how to interpret graphs of scientific data, starting on page 354 of your textbook. A review of the steps for making a graph is given on page 356.

Investigation

9 Science Directions

Refer to Activity 3-5 on page 137 of the textbook.

Note: Because air gives more dramatic results, you will use air rather than water in your containers.

5. What is the problem for this investigation?

6. Make a prediction about what will happen to the temperatures in the containers over 10 minutes. Will the containers have the same warming pattern?

7. What is the manipulated variable in this investigation?

_____

_____

8. What is the responding variable in this investigation?

_____

_____

Collect the materials required for the investigation. A 100-W lamp may be used if a 200-W lamp or flood lamp is not available. You will not require the stirring rod.

Do step 1 of the procedure. Place the light 10 cm from the containers if you are using a 100-W bulb, or 15 to 20 cm away if you are using a 200-W bulb. It is necessary to seal the holes around the thermometers with cotton batting or plasticine to prevent loss of heat. If the holes are plugged tightly around the thermometers, the bulbs of the thermometers can be suspended in mid-air inside the containers.

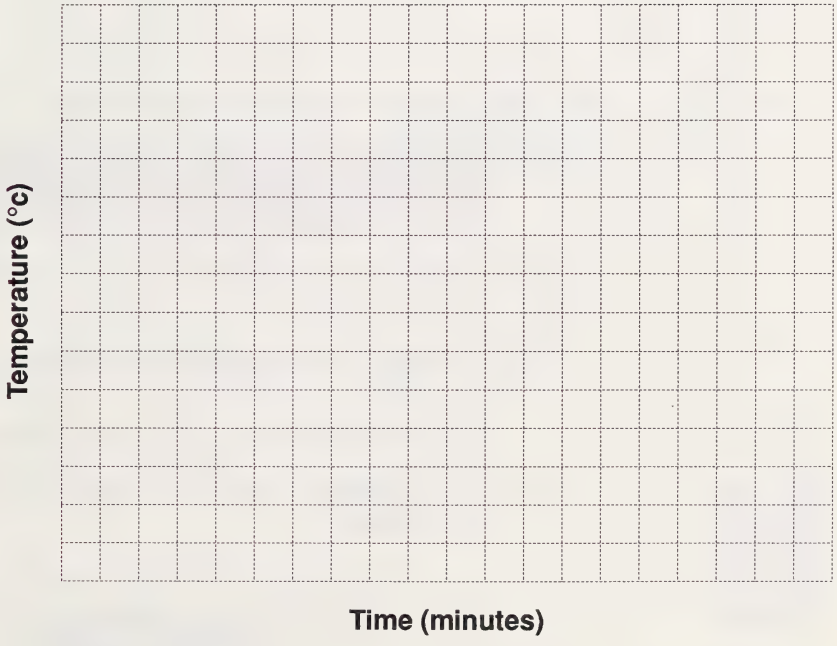
9. Record the temperatures of your samples in the following chart.

   Measure and record the initial temperatures in the containers and turn on the lamp. Measure and record the temperatures every minute for 10 minutes.

Time (minutes)	Temperature in Black Can (°C)	Temperature in Silver Can (°C)
0		
1		
2		
3		
4		
5		
6		

Time (minutes)	Temperature in Black Can (°C)	Temperature in Silver Can (°C)
7		
8		
9		
10		

10. Do step 5 of the procedure using the grid provided.



11. Do questions 1, 2, and 3 of Analysis on page 137 of your textbook.

Textbook question 1. (a):

_____

_____

Textbook question 1. (b):

Textbook question 2:

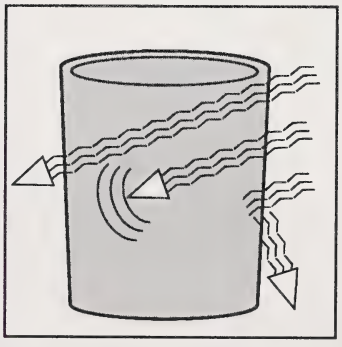
Textbook question 3:

Check your answers with your learning facilitator.

Activity 2: Properties of Radiant Energy

All types of radiant energy have some properties in common.

To find out about the properties of radiant energy, read pages 138, 139, and 140 in the textbook.



1. When radiant energy interacts with matter, the waves may be

   _____, _____, or _____.

   In the last investigation, light was _____ by the shiny or white can, _____ by the dull or dark can, and _____ by air.

2. What evidence tells us when radiant energy has been absorbed by an object?

   _____

   _____

3. Which of the three kinds of interaction of radiant energy with matter results in the greatest gain in energy for the material receiving the radiation? Explain your answer by telling what happens to the energy in all three interactions.

   _____

   _____

   _____

   _____

   _____

   _____

4. What is the usual relationship between an object's ability to absorb radiant energy and its ability to emit radiant energy?

   _____

   _____

Check your answers by turning to the Appendix, Section 3: Activity 2.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

1. Use the following word list to correctly fill in the blanks on the crossword puzzle. Each word will be used once.

Word List

sun	dull	transfer
waves	rays	television
shiny	infrared	reflect
radio	emitting	absorb
transmitted		

Clues

Across

(3) when waves pass straight through

(7) source of rays that allow life on Earth

(8) to move something to a new location

(11) a popular form of radiant entertainment

(12) this type of surface absorbs well

(13) can be AM or FM waves

Down

(1) this type of surface reflects well

(2) radiation travels in this form

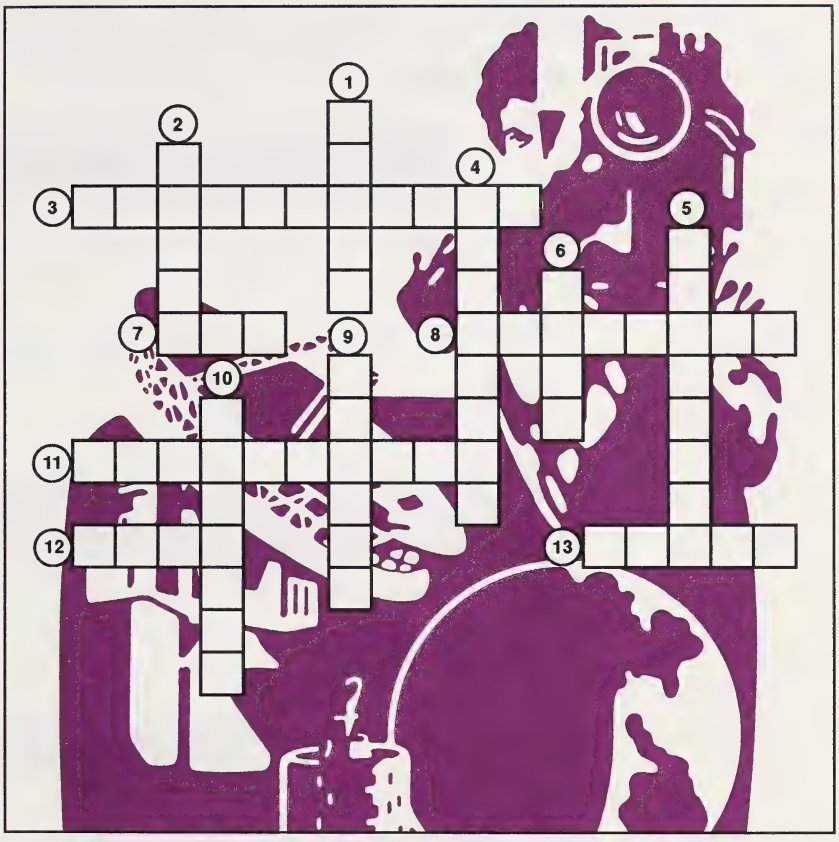
(4) sending out radiant energy

(5) another name for heat waves

(6) another name for waves

(9) to take waves in and keep their energy

(10) to bounce off of a surface



Check your answers by turning to the Appendix, Section 3: Extra Help.

2. Think of two examples which involve radiant heat energy and list them in the chart below. Beside each one, state briefly how heat radiation is involved. One example has been done.

Example	How Heat Radiation Is Involved
hot-water heating	hot water in a radiator radiates heat into the room

Discuss your answers with your learning facilitator.

Enrichment

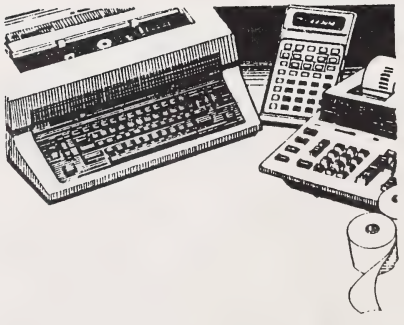
Do either Part A or Part B, or both.

Do Part A if you want to do some imaginative writing. Do Part B if you would like to do more laboratory work.

Part A

We tend to take some technology for granted. Throughout most of history people had very few of the conveniences that we enjoy today.

Read Did you Know? on page 138 of your textbook.



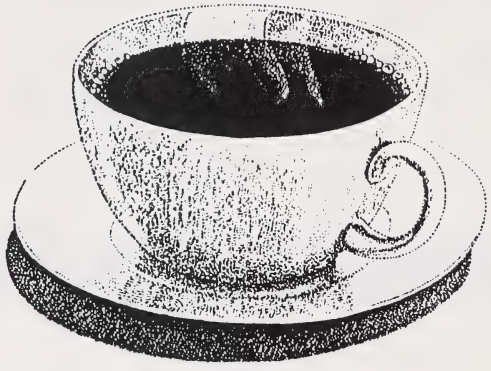
1. Imagine life without any technologies designed to produce and control radiant energy. Write a paragraph describing the ways that your daily life would be different if suddenly such technologies did not exist.

Share your answers with your learning facilitator.

Part B

Investigation

In the investigation earlier in this section, you observed the heating patterns of some metal containers and plotted the warming curves on a graph. What would the cooling curves look like? How would the cooling patterns be related to the warming patterns?



Problem

2. State the problem for an investigation to find out about the cooling of the same containers used in the previous investigation.

_____

_____

Caution: Domestic hot-water heaters are capable of producing water that is hot enough to scald your skin. Handle hot water carefully. Use oven mitts to handle metal containers containing hot water. Remember that metals conduct heat very well!

Materials

Collect the following materials.

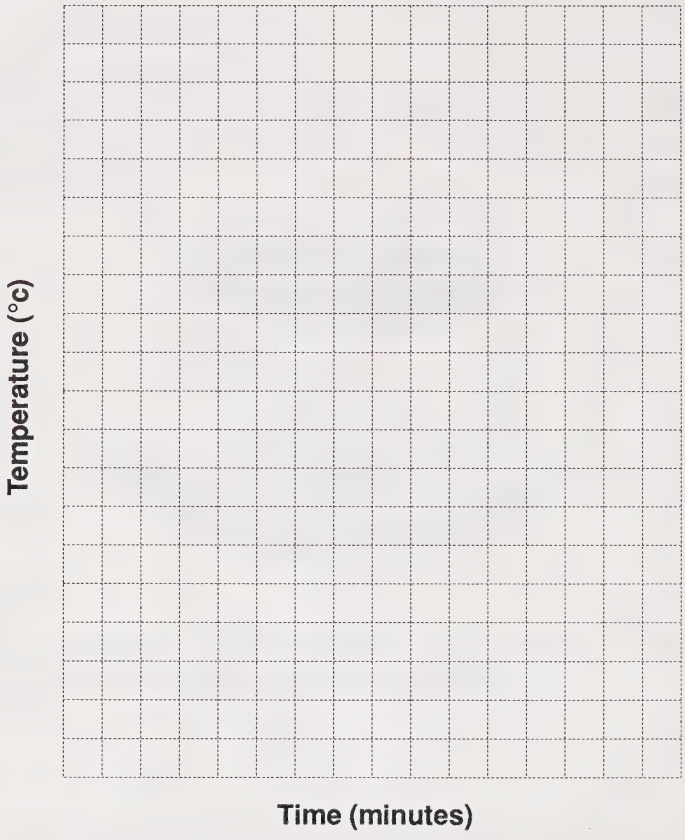
- two or more metal containers with contrasting surfaces/colours
- thermometer for each container
- stirring rod for each container
- timing device
- hot water from a hot-water tap
- cotton batting or plasticine

3. Prepare a chart in which to record your data during 15 minutes of cooling.

Put equal amounts of hot water into each of the containers to fill them about 2/3 full. Place the thermometers in the water at the same level. Seal the openings around the thermometers with cotton batting or plasticine.

Record the temperatures immediately. Continue to record the temperatures every minute for 15 minutes.

4. Plot a graph to show the cooling curves for the containers.



Analysing

5. What effect do the different surface colours have on the emission of radiant energy?

_____

_____

_____

_____

Discuss your answers with your learning facilitator.

Conclusion

In this section you learned about radiation, the third way that heat can be transferred from one place to another. After discovering the special nature of radiant energy waves and looking at the different forms of radiation in the spectrum, you completed an investigation and discovered that dark, dull surfaces absorb and radiate energy better than light, shiny ones. Finally, by studying the properties of radiant energy you gained a better understanding of how you can use technology to control the radiation of heat.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

Section

4

Controlling Heat Transfer

Western Canadians are very concerned about controlling heat transfer, especially during the winter. Look at the picture above. What is being done to prevent heat transfer?

In this section you will use your knowledge of conduction, convection, and radiation. After testing materials for their ability to prevent heat transfer, you will design, construct, and test a heat-control device. Following a discussion about insulation, you will learn how the earth is kept warm by its atmosphere.

Activity 1: Exploring Ways to Control Heat Transfer

Modern society considers it very important to control heat transfer. Why is this so?

Read the top paragraph on page 141 of the textbook and examine the illustration. Then answer the following question.

1. What is the reason given for our need to develop technology to control heat transfer?

_____

_____

Investigation

Refer to Activity 3-8 on page 143 of the textbook.

2. What are the two problems for this investigation?

   a. _____

   _____

b. _____

_____

Caution: When a light-bulb is used with paper, cardboard, or fabric, there is a possible fire hazard. The light-bulb must not touch other materials when it is turned on.

- Collect the materials that you will need to complete the investigation. You must test at least two of the materials that are on the list.
- Do steps 2, 3, 4, and 5 of the procedure using the plain box.

3. Record your data in the chart below.

Control Data for Cooling Box

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp. (°C)																

- Do step 6 of the procedure.

4. Record your data in the following charts. Write the name of the materials being tested in the spaces provided. If you are testing more than two materials, make more charts for your data on a separate sheet of paper.

a. **Cooling Data for Covered Box**

material: _____

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp. (°C)																

b. Cooling Data for Covered Box

material: _____

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp. (°C)																

- Do step 7 of the procedure.

5. Record your data in the chart below.

Cooling Data for Layers of Covering

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp. (°C) One layer																
Temp. (°C) Two layers																
Temp. (°C) Three layers																
Temp. (°C) Four layers																

6. Summarize what you have learned from this investigation by answering the questions that were asked in the problem section.

_____

_____

_____

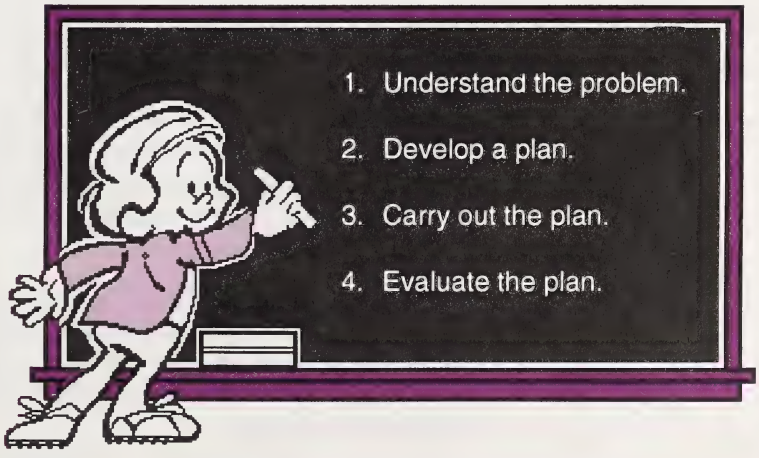
Discuss your answers with your learning facilitator.

Activity 2: Solving a Problem with Technology

You will soon be asked to solve a problem. Your solution will require you to design a device to prevent the loss of heat from a container of water.

When solving a practical problem by applying technology, a series of steps is usually followed. You may realize that you already use a similar set of steps to solve many everyday problems.

Technological Problem-Solving Model



First, you must **understand the problem**. This means that you should have a clear purpose in mind. You should also know what must be achieved. There may be a specific set of requirements or specifications that must be met.

Next, you need to **develop a plan**. Use your knowledge and perhaps refer to other sources of information to identify some alternative ways that the problem could be solved. There is always a variety of possible ways to solve a problem. You must choose what you think is the most practical plan.

The next step is to **carry out the plan**. This is when you actually construct the device that is needed to solve the problem. You may discover faults along the way which require you to make corrections or modifications to your plan. This is called "troubleshooting". It is very rare that any technology cannot be improved upon, and often compromises based on cost, availability of materials, or other practical considerations such as size, must be reached. In carrying out your plan, your job is to do the best you can with the materials at hand in a reasonable amount of time.

The last step is to **evaluate** how well your chosen plan has solved the problem. This testing stage may lead you to do further troubleshooting or to rethink your choice of plans. You might also decide that a different approach, perhaps one involving more research beforehand or the generation of more alternative plans, could improve your plan.

Keep this model in mind as you do the next investigation.

9 Science Directions

Investigation

Refer to Activity 3-6 on page 142 of the textbook.

1. What problem are you asked to solve in this investigation?

2. What materials would you choose to prevent conduction of heat? (Think about what you learned in the last investigation and in Section 1 of this module.)

3. What conditions must exist for convection to occur? (Think about Section 2 of this module.)

4. How can you discourage heat transfer by radiation from occurring? (Remember Section 3 of this module.)

Check your answers by turning to the Appendix, Section 4: Activity 2.

Next you will use your knowledge about how heat is transferred to help you design a device to keep heat from being lost by a sample of water. A Thermos™ is a commercial example of such a device. Try to be original and develop a new device to accomplish the same thing as a Thermos ™. Consider the points mentioned in step 2 of the procedure in Activity 3-6.

5. Make sketches of at least three alternative designs.

- Select the alternative which you believe to be the best.

6. Make a sketch of your selected plan in the space provided.

Next you will build your device and test it in an experiment where a measured amount of hot water is allowed to cool.

7. How much water will you use?

_____

8. How long will you allow it to cool?

_____

- Collect your materials and construct your device.

9. What changes did you make to your plan while constructing your device? Mention one example of troubleshooting during construction.

_____

_____

_____

_____

10. In the space below, make a chart in which you will record your data.

- Carry out the experiment to test your device. Record your data in the chart that you constructed.

11. How well did you solve the problem?

_____

_____

12. What would you change to make your design even better?

_____

_____

_____

_____

13. Give two examples of how you could conserve energy by using what you have learned in this investigation.

Check your answers with your learning facilitator.

Activity 3: Heat Insulators

You learned in the previous investigations that a material which prevents heat transfer can be used to insulate a container.

Read pages 144 and 145 in the textbook to learn more about heat insulators.

1. Fill in the following chart. One example has been done for you.

Insulator	Purpose
pink fibreglass	keeps walls from transferring heat
rubber wet suit	
	prevents burning hands on hot dishes
dead-air space	
	keeps waterfowl warm

2. What do the letters RSI stand for?

_____

_____

3. Use table 3-2 in your textbook to help you order the following insulating materials from best to worst.

blue polystyrene	brick	plywood
gypsum board	fibreglass	vermiculite

_____ best

_____

_____

_____

_____

_____ worst

4. Calculate the RSI value of white polystyrene that is 5 cm thick.

Check your answers with your learning facilitator.

9 Science Directions

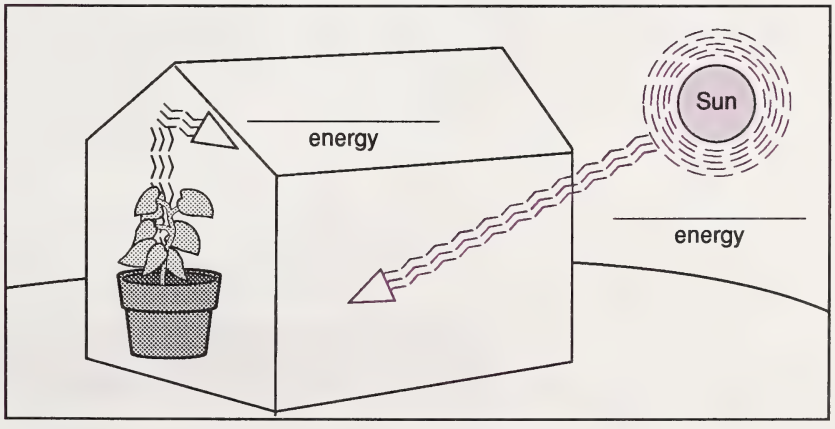
Activity 4: The Greenhouse Effect

There is no atmosphere around the moon. The surface temperature in the dark can be –180°C. The insulating effect of an atmosphere protects the earth from such extreme night-time temperatures.

For information on the greenhouse effect read page 146 in the textbook.

1. Why is the name *greenhouse effect* applied to the phenomenon that maintains a constant temperature on the earth?

2. Label the diagram below by filling in the blanks.



3. Draw a diagram of the greenhouse effect in Earth's atmosphere.

4. If there were an unusually high number of forest fires this year, would you expect any change in temperatures in the future? Explain your answer.

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

1. Use the words from the following list to correctly fill in the blanks in the following paragraphs. Each word will be used once.

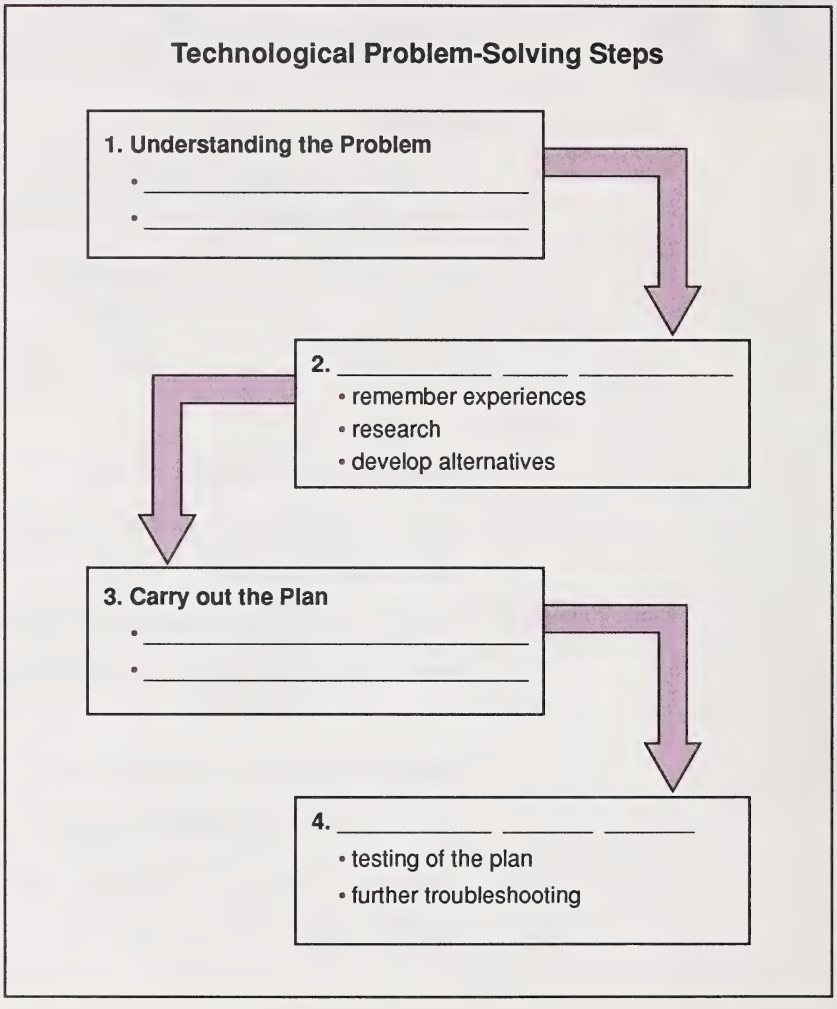
conservation	insulation	escape
transfer	absorbed	winter
non-renewable	RSI	improve
greenhouse	resists	radiation
heat		

When you know how to control heat _____, it is possible to make it happen more where you want it to and less where you do not. It is important for humans to _____ their energy efficiency because the _____ resources such as oil and gas will run out one day. Trying to save these resources is called energy _____.

Material that stops heat from being transferred is called _____. Heat insulators can be compared using _____ values. This value tells us how much 1 cm of the material _____ the transfer of heat.

The _____ effect happens because waves of light that get through the atmosphere easily are _____ when they strike the earth's surface. This energy converts to _____ and is re-emitted as infrared _____. Heat that is trapped in the atmosphere by carbon dioxide and water vapour cannot _____ into space easily. This results in a warming effect that keeps the surface temperature relatively warm, even in _____.

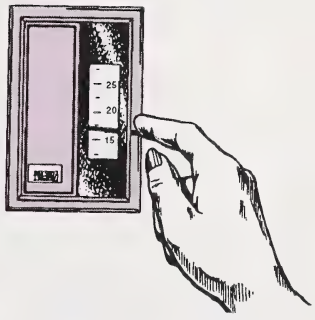
2. Fill in the following flow chart by providing correct information where some is missing.



Check your answers by turning to the Appendix, Section 4: Extra Help.

Enrichment

When a person hears that society is going to run out of fuel one day, it can be quite alarming news! Alternative energy sources have limitations and problems as well, but one thing that each citizen can do to help is to reduce their own consumption of energy. At least this way the energy supplies will last longer. There are also environmental benefits to this plan, since pollution will be reduced. A major site of personal energy consumption is the home. It seems sensible then that each person could have a great effect on the fuel supply by living in an energy-efficient home.



9 Science Directions

For an overview of Canada's ideal energy-efficient house, read pages 148 and 149 in the text.

1. List the six main features of the R-2000 home.

2. Many energy-efficiency improvements can be made to an existing home. Write a paragraph proposing some energy-saving improvements that could be made to your home. Assume that you have an unlimited budget, so cost is not a problem.

Share your answers with your learning facilitator.

Conclusion

This section has dealt with the transfer of heat energy. You have just learned about conduction, convection, and radiation of heat, and have tested some materials for their ability to prevent heat transfer. While following the steps in the technological problem-solving model, you designed, constructed, and tested a device to help prevent water from losing heat. You learned about insulation and RSI numbers and their importance in home construction. And lastly, you saw how the earth is kept warm by the atmospheric greenhouse effect.

The next section will cover an important property of substances that affects their ability to absorb, store, and transfer heat energy.

ASSIGNMENT

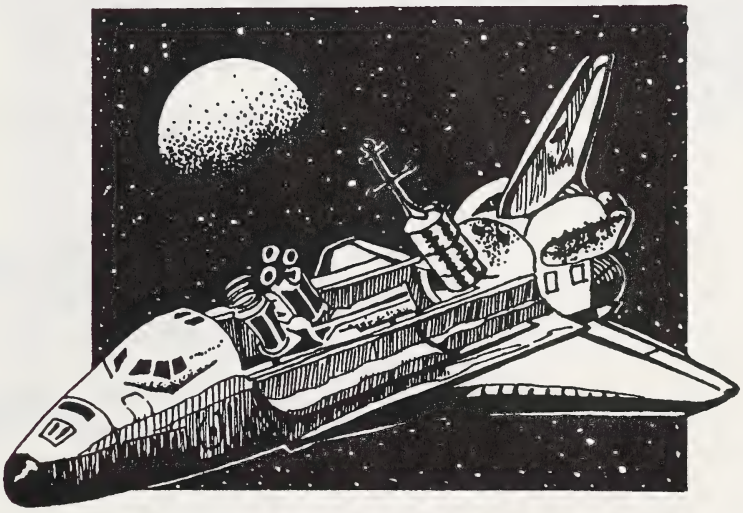
Turn to your Assignment Booklet and do the assignment for Section 4.

Assignment Booklet

Section

5

Heat Capacity



Re-entry into the earth's atmosphere can burn objects up because of the heat produced by friction, but technology based on knowledge about heat transfer makes it possible for the space shuttle and its crew to come home safely.

In this section you will make an interesting discovery about the way that liquids warm up. This is a special characteristic of all substances called **heat capacity**. By the end of the section you will also discover that the amount of heat given up by one object will be equal to the amount of heat gained by surrounding objects.

Heat capacity: the ability of a substance to hold heat

Activity 1: Heating Liquids

The fact that substances have different abilities to retain heat can have some interesting effects.

9 Science Directions

Have you ever thought about living in Victoria, B.C.? Read page 150 in the textbook to see why you might like to move there.

Investigation

9 Science Directions

Refer to Activity 3-9 on page 151 of the textbook.

1. What is the problem for this investigation?

_____

_____

_____

Collect the materials required for this activity. If a balance is not available, use a 100 mL graduated cylinder. Do step 1 of the activity. Be sure to allow the burner to reach a constant temperature before you begin heating the liquids.

2. Do step 3 of the procedure. If a balance is not available, you may determine the number of mL of liquid required to obtain a 100 g mass by using the following table. Use a graduated cylinder to measure the volume required for 100 g of mass. Repeat step 3 for all three liquids.

Substance	Density (g/mL)	Volume Required for 100 g mass (mL)
glycerol (or corn syrup)	1.26	79
water	1.00	100
vegetable oil (or similar oil)	0.92	109

3. Which of the liquids do you predict will heat up the fastest?

_____

4. The following table will be used to record data for this demonstration. Record the names of the three liquids that you plan to use in the spaces at the top of the table.

Heating Liquids

Time (minutes)	Temperature of _____ (°C)	Temperature of _____ (°C)	Temperature of _____ (°C)
0.0	30	30	30
0.5			
1.0			
1.5			
2.0			
2.5			

Time (minutes)	Temperature of _____ (°C)	Temperature of _____ (°C)	Temperature of _____ (°C)
3.0			
3.5			
4.0			
4.5			
5.0			
5.5			
6.0			
6.5			
7.0			

5. Do steps 4 and 5 of the procedure. Record your data in the table provided. You will record the temperatures of the three liquids every 30 seconds. For each liquid, timing will begin when the temperature reaches 30°C and stop when the temperature reaches 70°C.

Caution: Do not let the thermometer touch the bottom of the container during heating. This will prevent high readings due to direct conduction of heat through the bottom of the beaker.

6. Do questions 1 and 2 of Analysis.

   Textbook question 1:

   _____

   Textbook question 2:

   _____

   _____

7. Do questions 3 and 4 of Further Analysis.

   Textbook question 3:

   _____

   Textbook question 4:

   _____

   _____

As you have discovered, water needs a large amount of heat to increase its temperature.

Read the top of page 152 in the textbook for more information about water's capacity to hold heat.

8. What is one application of water's high heat capacity that is given in the textbook?

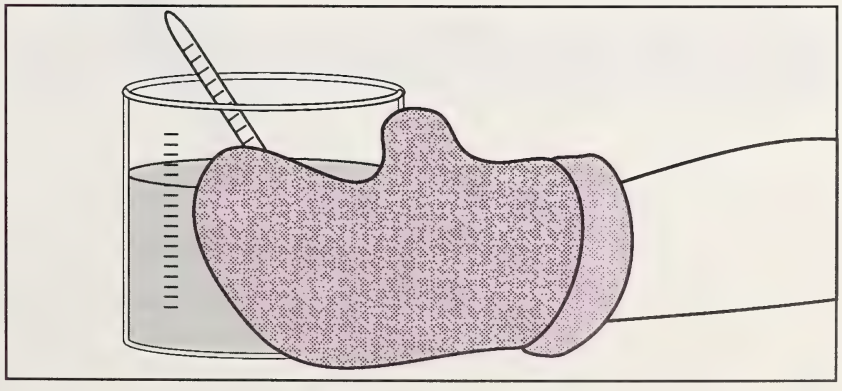
   _____

Check your answers with your learning facilitator.

Activity 2: Specific Heat Capacities

Specific heat capacity: the amount of energy, in joules, that it takes to cause a 1°C temperature change in 1 kg of a substance

It is useful to be able to compare the **specific heat capacities** of substances.



9 Science Directions

Read the bottom of page 152 and the top of page 153 to learn how this is done.

1. In the metric system, heat is measured in units called _____. The symbol for this unit is _____. The amount of energy that it takes to change the temperature of 1 kg of a substance by 1°C is called its _____ _____ _____.

2. The unit of specific heat capacity, stated using symbols, is _____. The specific heat capacity of water is _____ J/kg°C. This means that it takes _____ J of heat to cause a temperature change of _____ °C in 1 kg of water.

Check your answers by turning to the Appendix, Section 5: Activity 2.

3. A 1 kg sample of water received 8400 J of heat and its temperature rose by 2°C. If another 16 800 J of heat are transferred into it, the temperature will go up by _____ °C.

4. If a 1 kg sample of ethanol (check table 3-3 on page 153) receives 5000 J of heat, its temperature will go up _____ °C. If given the same amount of heat, a sample of ethanol half as big (500 g) would experience a rise in temperature of _____ °C.

5. When put into the refrigerator, a 1 kg sample of vegetable oil lost 10 000 J of heat, so the temperature would have gone down by _____ °C. To have the temperature go down by 20°C, _____ J of heat must be lost. If this amount of heat was transferred out of a 2 kg sample of vegetable oil, the temperature would go down by _____ °C.

6. If 920 J of heat were added to a sample of aluminum to increase its temperature by 1°C, _____ J of heat would need to be added to raise its temperature by 3°C.

7. To lower the temperature of a 10 kg block of brass by 10°C, you would have to remove _____ J of heat.

8. 5 kg of ethanol and 5 kg of ethylene glycol both had their temperatures raised by 1°C. Which substance would have required more joules of heat?

_____

Check your answers with your learning facilitator.

Activity 3: Heat Transfer

Do you ever have trouble getting the water temperature just right for washing dishes or taking a shower? One reason that you can adjust the water temperature is that heat energy is never lost. It always has to go somewhere.

Read the bottom of page 153 as well as page 154.

1. What is the scientific law that states "Energy is never created or destroyed"?

   _____

2. When you try to adjust the water temperature at a faucet, where else does the heat from the hot water end up, besides in the cold water?

   _____

   _____

For the following questions, assume that the mixing of the samples is taking place in a perfectly insulated container so that no heat escapes. Choose from the following values to answer the questions. Not all the values will be used.

Values: 40, 50, 60, 70, 80

3. If 100 mL of water at 80°C are mixed with 100 mL of water at 40°C, the final temperature of the mixture should be _____ °C.

4. If 200 mL of water at 80°C are mixed with 100 mL of water at 50°C, the final temperature of the mixture should be _____ °C.

5. If 100 mL of water at 80°C are mixed with 200 mL of water at 50°C, the final temperature of the mixture should be _____ °C.

Check your answers by turning to the Appendix, Section 5: Activity 3.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Solve the following puzzle by using the words in the word list to answer each clue. Place the words in the spaces, letter by letter, to reveal something that is very important to think about when you are talking about heat!

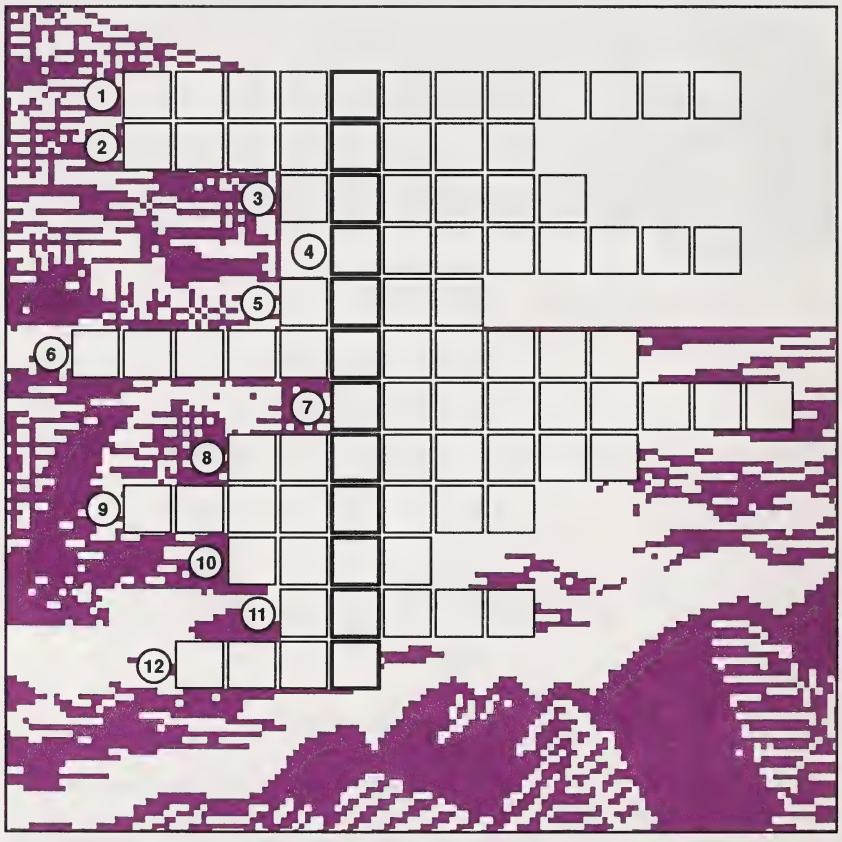
Word List

gain	vegetable	equation
joule	iron	heat capacity
hydrogen	energy	temperature
heat	specific	transfer

Clues

1. the ability to hold heat
2. a gas with a very high specific heat capacity
3. the ability to do work – heat is one form
4. the kind of heat capacity for raising the temperature of 1 kg by 1°C
5. what causes the temperature to rise
6. measured by a thermometer

7. oil whose specific heat capacity is 2000 J/(kg°C)
8. to move from place to place
9. words or symbols arranged around an equal sign
10. to get more of something
11. the SI unit of energy
12. metal whose specific heat capacity is 450 J/(kg°C)



Solution: An important thing to think about when you are talking about heat is

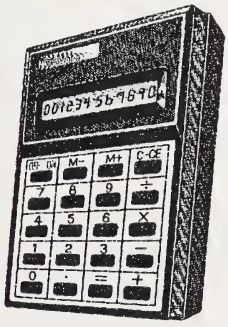
_____.

Check your answers by turning to the Appendix, Section 5: Extra Help.

Enrichment

Do either Part A or Part B, or both.

Do Part A if you like to solve mathematical problems. Do Part B if you would like to do further investigations.



Part A

You have already seen that the heat energy, mass, specific heat capacity, and temperature change of an object are related in an equation. To see how the equation looks when symbols are used to represent the variables in the situation, read Using Symbols in Equations on page 155 of the textbook. To examine how the equations can be put to work, read the top of page 156 in the textbook.

1. Do questions 1, 2, and 3 in Activity 3-10 on page 156 of the textbook. Show your work.

   Textbook question 1:

   mass of mercury =

   E =

   Δt =

   formula: c =

   answer =

   statement:

Textbook question 2:

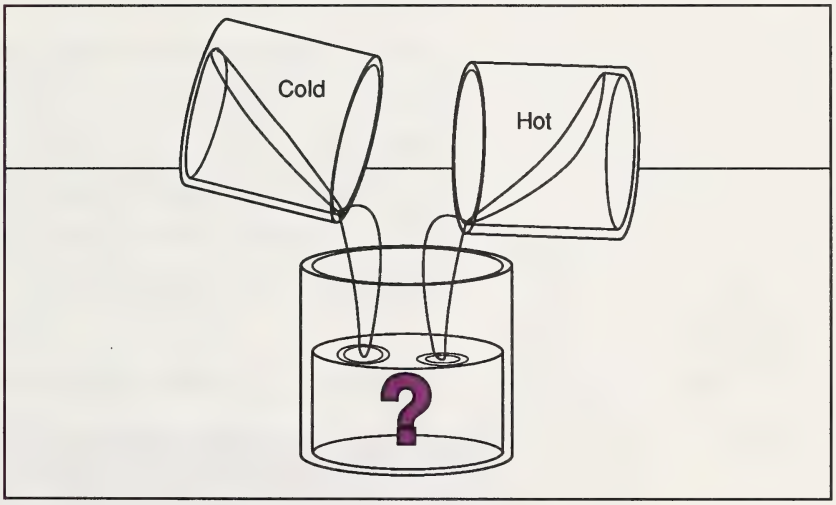
Textbook question 3. (a):

Textbook question 3. (b):

Check your answers with your learning facilitator.

Part B

In this section you learned that when you mix two samples of water at different temperatures, the resulting mixture should have a predictable temperature. You were also told that not all the heat that is lost by the hot water goes into the cold water because the heat gets transferred to other places as well. In the following investigation you will have an opportunity to make and test some predictions about the final temperatures of mixtures of water.



Investigation

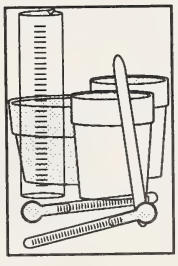
Problem

The problem for this investigation is to determine the final temperatures of mixtures of various proportions of hot and cold water.

Materials

Gather the following equipment.

- two beakers or plastic cups
- two thermometers
- stirring rod
- graduated cylinder or measuring cup
- large container for mixing water samples
- hot and cold water



Procedure

2. Determine the capacity of your mixing container by filling it almost to the top with water and then pouring the water out into the graduated cylinder. Each time that you fill the graduated cylinder record the total. Do this until your container is empty. The total capacity of the mixing container is _____ mL. The amounts of hot and cold water you mix cannot add up to more than this limit.

3. For each of the five mixtures you will be making, determine beforehand how much cold and hot water you will use and enter the amounts into the following chart. Storing the water in a poorly conductive container will prevent some heat transfer, but you should work fairly quickly to determine the temperatures of the two samples, record them in the chart, and mix the samples together using the stirring rod. Take a moment to record a prediction of the final temperature before measuring and recording the actual final temperature. Repeat this procedure five times, each time selecting different proportions of hot and cold water.

Mixing Hot and Cold

Cold Water		Hot Water		Mixture Temp.	
Amount (mL)	Temp. (°C)	Amount (mL)	Temp. (°C)	Prediction (°C)	Actual (°C)

Analysis

4. Make a statement about how close your predictions were to the actual final temperatures. Were your predictions usually low or high?

5. Does it appear that all of the heat lost by the hot water is gained by the cold water?

6. Where else could the heat be transferred to, besides the cold water?

Discuss your answers with your learning facilitator.

Conclusion

After discovering that different liquids take different amounts of time to warm up, you learned that different materials have different capacities to hold heat. Specific heat capacity is used to compare different substances' responses to both gaining and losing heat. The Law of Conservation of Energy and the Principle of Heat Transfer helped you to understand what happens when hot and cold objects come in contact and heat is transferred.

Assignment Booklet

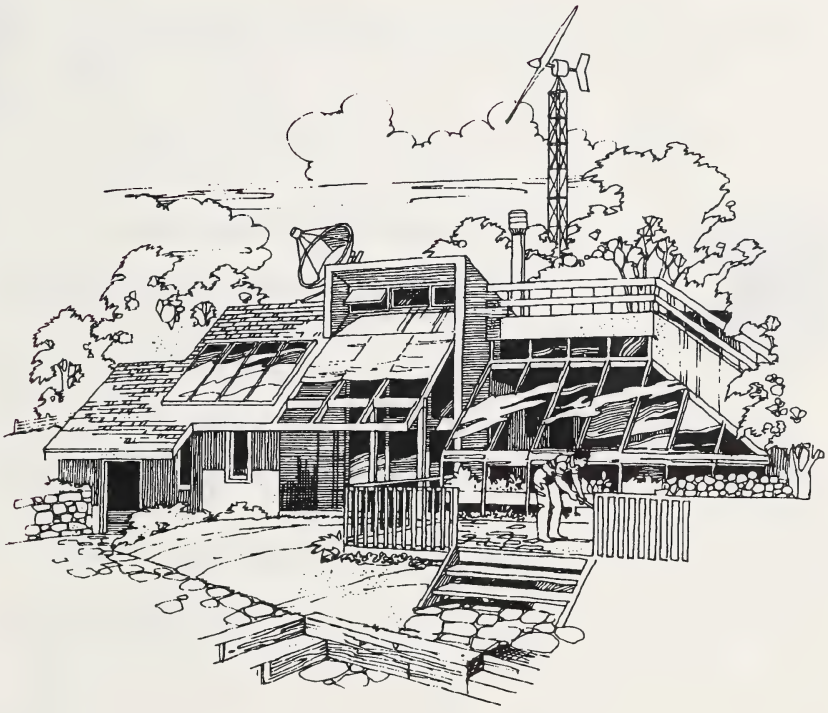
ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 5.

Section

6

Solar Heating



Have you ever seen a house like this? Maybe you live in one. Solar homes are becoming more common all the time because of improvements in heat-transfer technology.

In this section you will be learning about different types of solar heating systems. The information you gain will assist you in designing and constructing a model of a solar home.

Activity 1: Passive Solar Heating

People are looking to the sun as one reliable source of energy for the future.

9 Science Directions

For a further discussion about energy resources, read page 157 in the textbook.

1. What is the difference between renewable and non-renewable energy resources?

_____

_____

_____

2. Name five renewable energy resources.

_____

_____

_____

3. What four topics that you have already studied in this module are involved in solar heating technology?

_____

_____

9 Science Directions

Read page 158 in the textbook, including Did You Know?, to find out about passive solar heating.

4. Describe what *passive* means in reference to solar heating.

_____

_____

5. What are two reasons that passive solar heating is popular?

_____

_____

6. Describe three design features that windows can have to assist passive solar heating.

_____

_____

_____

7. Explain how deciduous trees on the south side of the house can help keep the house warm in winter and cool in summer.

_____

_____

_____

_____

8. Why would evergreen trees be placed on the north side of the house?

_____

_____

_____

_____

9. How can your choice of construction material affect how warm you will be in the house at night?

_____

_____

_____

_____

10. Explain how termite mounds take advantage of passive solar heating.

Check your answers with your learning facilitator.

Activity 2: Active Solar Heating

Many homes already use passive solar heating to assist in keeping interior temperatures at a comfortable level. However, there are ways to take more control over the distribution of solar heat in homes and buildings.

Read pages 159 and 160 in the textbook to find out about active solar heating systems.

9 Science Directions

1. What is the basic difference between passive and active solar heating systems?

2. What type of material is usually used to absorb and distribute heat in an active system? Why is this a good choice?

3. Why is it important to aim solar collectors towards the south?

9 Science Directions

4. Copy the diagram of a flat solar collector found at the bottom of page 159 in your textbook.

5. What is the function of the double glass plates on top of the flat collector?

_____

_____

6. What makes copper a good choice of material for the water pipes?

_____

_____

7. What is the purpose of the insulation under the water pipes?

_____

_____

8. What two things make the liquid circulate in an active collector system?

_____

_____

9. Explain the use of curved solar collectors like the one in the photograph on page 160 of your textbook.

_____

_____

_____

9 Science Directions

10. What does an automatic tracking system do for a solar collector?

_____

_____

11. Explain one advantage and one disadvantage of using antifreeze in active solar heating systems.

_____

_____

_____

Check your answers by turning to the Appendix, Section 6: Activity 2.

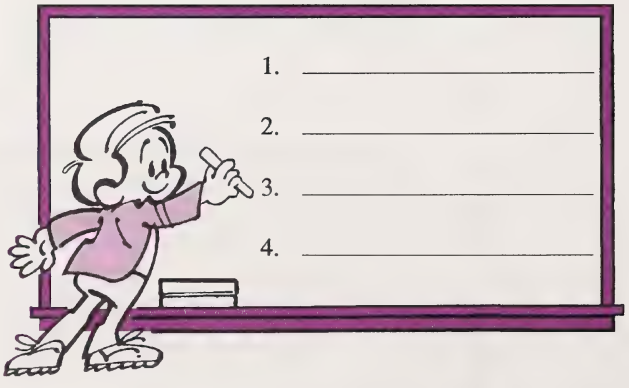
Activity 3: Building a Model Solar Home

The importance of technology is that practical problems can be solved. With the knowledge you now have about heat transfer, along with the experience in designing, constructing, and testing devices, you are well-equipped to meet another challenge.

Investigation

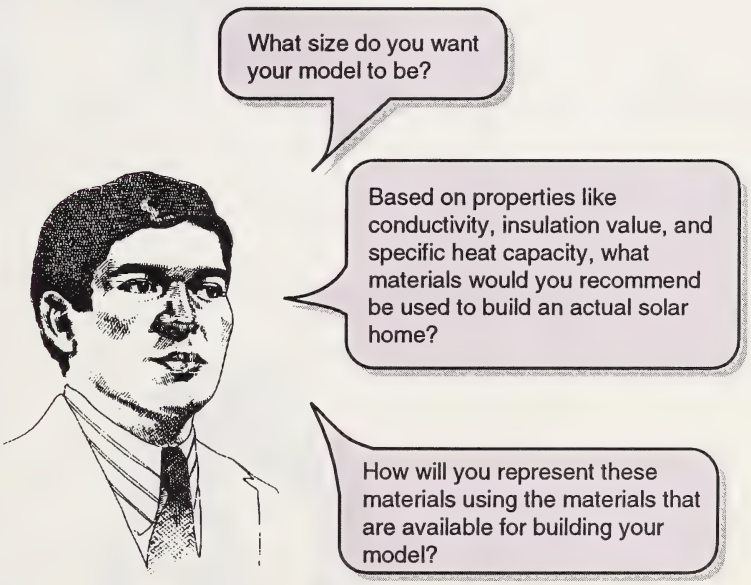
Keeping in mind the steps of the technological problem-solving model, you will soon design and construct a model of a solar home. You will be concentrating on understanding the problem, developing a plan, and then carrying out the plan to the extent of making a model solar home.

1. Fill in the steps that you will take by following the technological problem-solving model.



Your model is meant to be a representation of a home that uses solar heating technology. The features do not have to actually function. The main structure can be made of cardboard, wood, or plastic. The various solar features can be drawn or built onto the model. Colour and texture can be used to represent the materials that you would recommend for use in an actual home. Interior features can be displayed by use of a removable roof or a drawing of the floor plan. Landscape features can be represented with construction paper or plastic models arranged around the home.

Consider the following points when planning your home:



What features of passive solar heating do you want to incorporate into your model? Think about features that collect energy passively and release it slowly.

What features of active solar heating do you want to incorporate into your model? Think about features that collect, store, and distribute heat actively.

What floor plan will you use? Which rooms do you want to be in the sun at different times of the day? For example, you might want the morning sun to warm your breakfast table, or you may want your TV room in a cool, shaded room.

How can you landscape using vegetation and landforms such as hills to influence the wind and sun that your home receives?

In which directions will you have the walls, windows, solar collectors, and other features of the home facing? Be sure to indicate the orientation of your model with an arrow that points north.

You will be marked on your attempt to incorporate elements of both passive and active solar heating.

Problem

2. From the information given so far in this investigation, what is the problem for this investigation?

3. What passive solar features will you include in your solar home?

4. What active solar features will you include in your solar home?

5. What interior floor plan considerations will you include to use the position of the sun to your advantage?

6. What landscaping considerations will you include to use the positioning of vegetation to your advantage?

_____

_____

_____

_____

Materials

Any of the following materials may be used along with other materials that have been approved by your learning facilitator.

- aluminum foil
- wire
- plywood
- straws
- tin cans
- cardboard (boxes)
- plastic
- popsicle sticks
- string
- wallpaper scraps
- coloured paper
- plastic wrap
- poster paint
- tape
- white hobby glue
- insulating materials (polystyrene, fibreglass, and various types of cloth)

Procedure

7. Make three or four drawings of home designs that you could build. Afterwards, highlight the one that you think is best.

Discuss your plans with your learning facilitator.

- Construct your model solar home.

Analysis

8. What changes did you make to your plan while making your model home? Give one example of troubleshooting during construction.

_____

_____

_____

_____

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Select words from the following list to correctly complete the crossword puzzle.

Word List

passive	water	solar
active	antifreeze	shutters
window	pump	electricity
collector	south	convection
absorbing	north	curved
copper	tracking	

Clues

Across

1. energy from the sun
4. the direction in which the sun is usually found
5. a device to help circulate liquid in a system
6. a device to gather solar energy
7. added to water in a collector to prevent damage in subzero temperatures
8. needed to run the pumps in an active system
12. a good liquid for solar collectors
13. what the collector surface does with solar energy
16. a glass-covered opening in your home

Down

2. the type of system that absorbs, stores, and distributes heat
3. a good metal to use for collector pipes
6. the natural flow in a heated fluid

6. the natural flow in a heated fluid

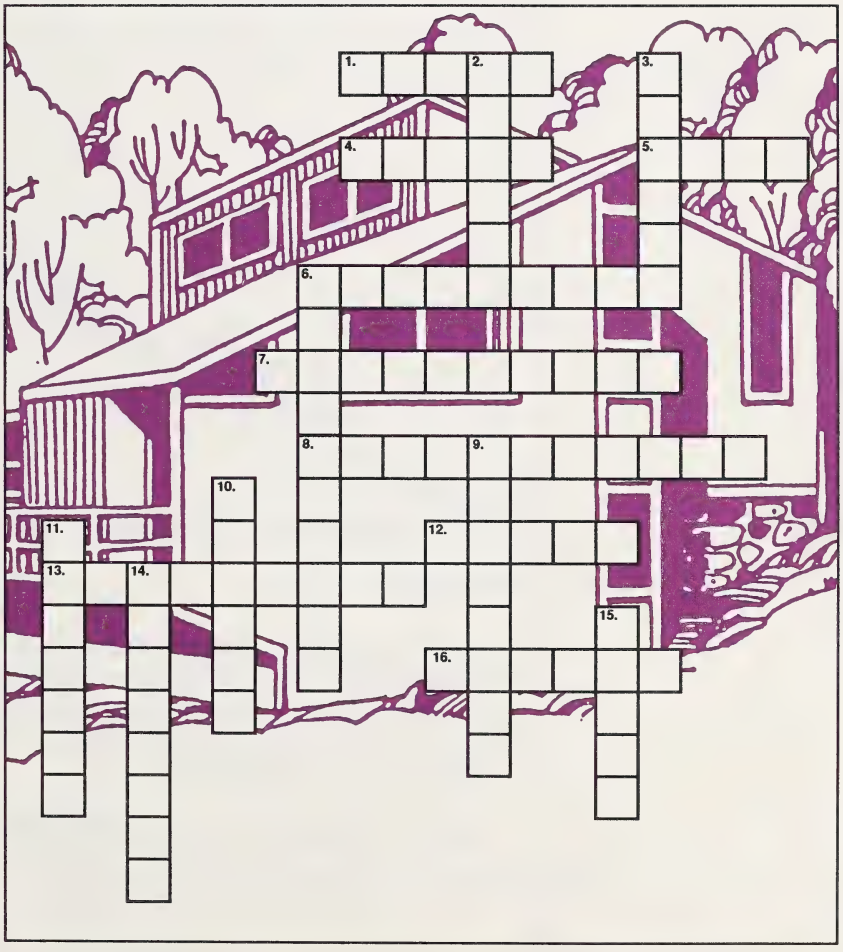
9. following the sun

10. the shape of collectors which focus energy on one spot

11. a system that just allows solar energy in and prevents it from leaving

14. exterior solid window coverings which can open or close as needed

15. the side of the house where the cold winter winds hit



Check your answers by turning to the Appendix, Section 6: Extra Help.

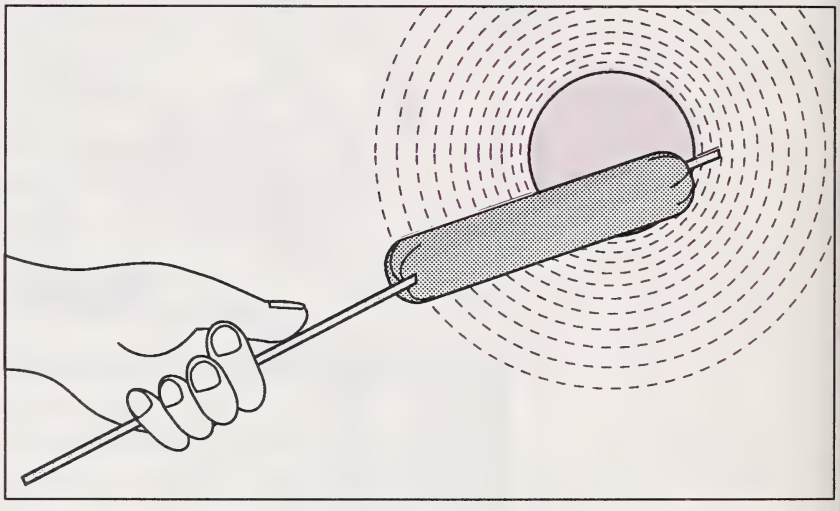
Enrichment

Do either Part A or Part B, or both.

Do Part A if you want to build and test another device. Do Part B if you would like to do some writing.

Part A

Investigation



Problem

Design and construct a solar cooker! You can get ideas from other sources, but looking at some of the information in the textbook in a creative way could give you some interesting ideas. For example, how might a design for a curved collector be put to use in cooking? Could the construction of a flat collector be adapted to produce a solar oven?

Test it by cooking a hot dog or marshmallow on a sunny day.

Procedure

1. Draw and label a sketch of your solar cooker. Build your cooker according to this design with materials that are available to you.

2. Explain how your cooker is expected to function.

_____

_____

_____

_____

Analysis

3. After testing the cooker, report on how well it worked.

_____

_____

_____

4. What aspects of your design would you try to improve if you were to build another cooker?

Share your answers with your learning facilitator.

Part B

Did you ever think that the study of heat transfer could turn into a career?

Read about Alan Nursall on page 162 in your textbook.

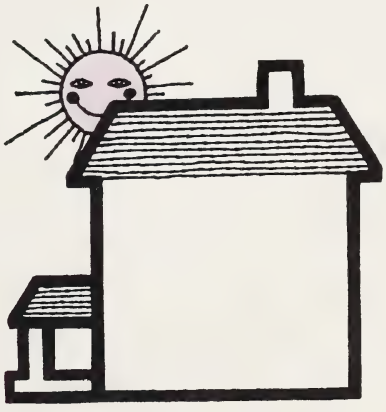
9 Science Directions

5. Write a paragraph telling about what it is that Alan finds exciting about his studies and his career. What non-scientific things does Alan do in his job? What do meteorologists actually do?

Share your answers with your learning facilitator.

Conclusion

In this section you learned about passive and active solar heating systems. This information, along with your knowledge of heat transfer, helped you to design and construct a model solar home.



ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 6.

Assignment Booklet

MODULE SUMMARY

During the study of this module you have learned how to use technology to control the transfer of heat energy. After examining the causes and control of conduction, convection, and radiation, you applied your knowledge to designing, constructing and testing a container to conserve the heat of a water sample. Specific heat capacity provided an explanation for the differing amounts of temperature change that occurs in various substances. Keeping the Law of Conservation of Energy in mind, you looked at the effect of mixing hot and cold substances and predicted the final temperatures of mixtures of hot and cold water. The culmination of the module came in the study of passive and active solar heating systems. This information, along with your previous learning, helped you to design and construct a model solar home.

Appendix

Glossary

Active solar heating
- a system that uses a collector to absorb solar energy as heat and redistributes it using a liquid

Conduction
- transfer of heat by direct collision between particles of matter

Conductometer
- a device used to demonstrate the rate at which heat is conducted by several metal rods

Convection
- the transfer of heat by the circulating motion of a fluid

Convection current
- the circulating movement of a fluid caused by the application of heat

Greenhouse effect
- the trapping of radiant energy from the sun when energy striking the earth is re-emitted as heat and held in the atmosphere by carbon dioxide

Heat
- energy transferred because of a temperature difference

Heat capacity
- the ability of a substance to hold heat

Heat conductor
- a material that allows heat to transfer through it easily

Heat insulator
- a material that helps to prevent the transfer of heat

Hydroelectricity
- electricity generated from the movement of water

Infrared radiation
- heat energy being transferred as waves

Law of Conservation of Energy
- the assertion that energy is never created or destroyed Although energy may change form, the total is always conserved.

Non-renewable resource
- a resource that exists in limited supply Coal and oil are non-renewable resources.

Passive solar heating
- a system that simply lets solar energy in and prevents much of it from leaving

Principle of Heat Transfer
- the idea that heat lost equals heat gained

R-2000 Home
- a program to build homes with a maximum of insulation and other features designed to conserve energy

RSI value	• a measure of an insulator's resistance to the transfer of heat stated per cm of thickness
Radiant energy	• energy transmitted by means of radiation
Radiation	• transfer of energy in a wave-like form
Renewable resource	• a resource that is not limited, such as solar or hydroelectric resources
Solar energy	• radiant energy from the sun
Specific heat capacity	• the amount of energy, in joules, that it takes to cause a 1°C temperature change in 1 kg of a substance
Temperature	• a measure of the average energy of the particles in a substance
Thermal	• an up-draft caused by the rapid heating of land areas in the morning sunlight
Thermal energy	• the total energy of all the particles in a substance
Thermal conductivity	• the ability of a substance to conduct heat

Suggested Answers

Section 1: Activity 1

1. The reaction shown by the girl in the picture indicates that the metal spoon is hot.

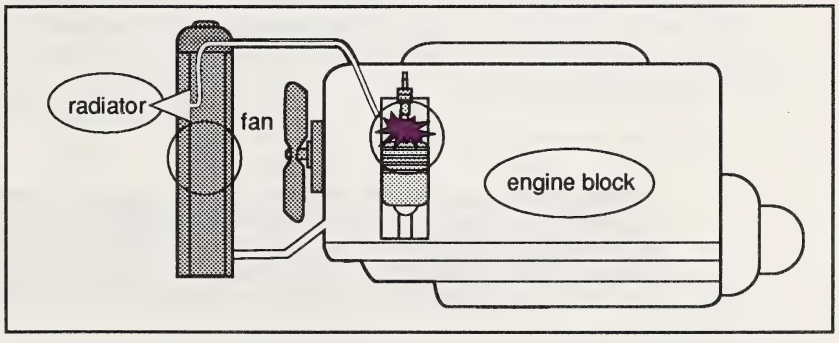
Section 1: Activity 3

1. When energy is added to the particles of a substance, they begin to move more rapidly, so the metal particles at the end being heated are speeded up. As those particles bump into other particles, the energy is transferred from one to another and the heat passes along the metal rod.

2. Substances that readily allow heat to transfer through them are known as heat conductors.

Section 1: Activity 4

1. If human skin and tissue conducted heat very well, a heating pad would cause overheating in a short time and a cold pack would cause extreme cooling of the flesh. Either could cause damage to the person's body.

2. 

3. Any metal with a low conductivity would be a poor choice for radiator material. You may have listed iron, steel, or brass from Table 3-1 in the text.

Section 1: Follow-up Activities

Extra Help

1. As energy is given to the first domino, it begins to move, much like particles of matter. When the domino collides with another, it has the effect of increasing the motion of the one it hits by transferring energy to it. In this way energy is conducted down the line of dominoes.

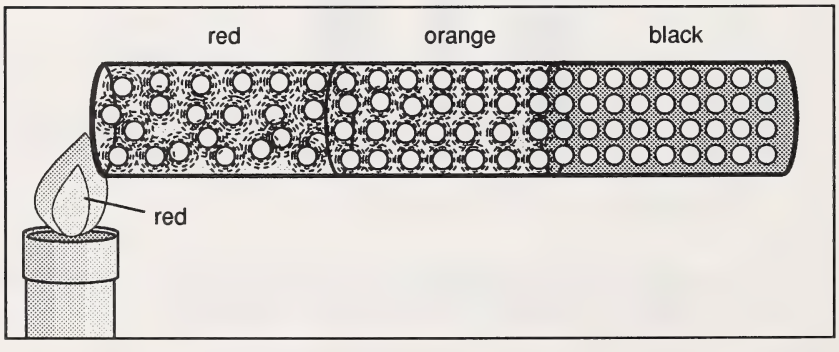
2. A material must allow heat to transfer through it in order to be called a good conductor.

3. Metals are good conductors beause of the large number of free electrons allowed to move within the substance.

4. Knowing how heat moves from one place to another helps you control heat. One way that heat can be transferred from place to place is by **conduction**. Conduction happens when a moving particle with lots of energy collides with a slower particle with **less** energy. Bumping into the slower particle transfers **energy**. This speeds up the motion of the slower particle.

   Imagine two people walking down the street towards each other and bumping into each other. They are both going to get a little shaken up. Now imagine that one of them is running. If they collide, a lot of energy is going to be transferred!

   Particles of matter behave in a similar fashion. A hot particle which has picked up heat energy from a heat source such as a flame begins to vibrate very **quickly**. When it collides with another particle, some energy will be **transferred**. The second particle will start to **vibrate** more quickly too. You can see this illustrated in the diagram at the bottom of page 124 in the textbook.

5. 

6. You should describe that the particles are moving due to energy and that the particles at the hot end are getting more energy and are therefore moving more quickly. The increased motion leads to collisions which cause energy to be passed along from particle to particle.

Enrichment

2. Textbook question 5. (a):

   The copper bottom of the pot will quickly transfer the heat from the stove element because copper has a high thermal conductivity. The steel sides and lid are not as conductive and will not tend to transfer heat away from the pot as readily as copper would. Heat is therefore held in the pot.

   Textbook question 5. (b):

   The plastic handle of an iron is not very conductive and does not allow much heat to be transferred to a person's hand.

   Textbook question 5. (c):

   The highly conductive metal transfers more heat into the potato than there normally would be. This causes the potato to cook more quickly.

   Textbook question 6:

   If air was highly conductive, large amounts of heat would be transferred away from your skin, making you feel cold.

   Textbook question 7:

   Although a dry sponge does contain some solid material, it is mostly full of air, which is not a very good conductor.

Section 2: Activity 2

1. Particles directly above the heat source gain energy and start moving more quickly than before. They spread out and push other particles away, causing that area of the fluid to become less dense. The warm, less dense fluid rises and is replaced by cooler, more dense fluid. This causes a complete current to form.

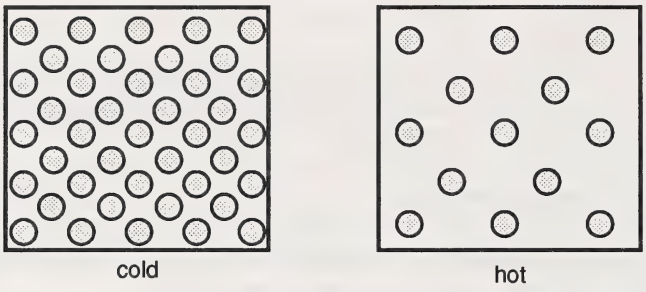
2. The particles of a solid are not free to flow.

3. In conduction the particles are stuck in place and heat is transferred from one particle to another. In convection the particles are free to move and carry the heat along with them.

Section 2: Follow-up Activities

Extra Help

1. Since hot air rises, placing the heat souce in the basement uses the natural formation of a convection current to transfer heat throughout the house and bring cool air to the furnace.

2. 

3. The video uses the term *buoyancy* to explain what causes convection.

4. Conduction is a good way for heat to move in **solids**. In fluids **conduction** does not work very well. Instead, in both liquids and gases, **convection** occurs. Because the particles of **fluids** are free to flow, they tend to move around, rather than vibrate in place and pass their energy to their neighbours. When a fluid gains **energy**, the particles near the heat source begin moving more rapidly and spread out as they collide more often, pushing each other away. This makes the fluid less dense where the **warmer** particles are found. The less dense parts of the fluid tend to rise above the **more** dense parts. This rising of one part and falling of another sets up a **convection current**.

5. As the particles in a fluid become warm, they gain energy and their motion increases. This causes them to collide more often, pushing each other away.

6. A hot gas would go up when released into a room.

7. Cold air tends to fall.

Section 3: Activity 1

1. You could have listed any of the forms shown on the spectrum in the textbook, including radio waves (long wave, AM, FM, TV, radar, or microwave), heat waves (infrared radiation), visible light, ultraviolet light, X rays, and gamma rays.

2. The complete range of forms of radiation can be called a **spectrum**.

3. Radiant energy is transmitted as waves. Different types of waves have different amounts of energy. The lowest energy waves in the spectrum are **radio** waves and the highest energy waves are **X rays or gamma rays**. The most dangerous waves are the **highest** energy waves.

4. Both conduction and convection require particles of matter, but radiation transfers energy as waves and can travel through a vacuum.

Section 3: Activity 2

1. When radiant energy interacts with matter, the waves may be **reflected**, **absorbed**, or **transmitted**.

   In the last investigation, light was **reflected** by the shiny or white can, **absorbed** by the dull or dark can, and **transmitted** by air.

2. When energy is absorbed, a rise in temperature occurs.

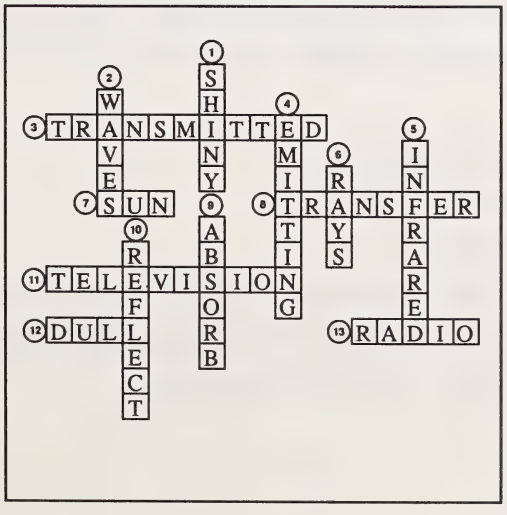
3. Absorption results in the greatest gain in energy since the energy is kept by the material. Reflection causes the energy to bounce away from the material, and transmission allows the energy to pass right through the material.

4. Generally, good absorbers are also good emitters.

Section 3: Follow-up Activities

Extra Help

1.



2.

Example	How Heat Radiation Is Involved
hot-water heating	hot water in a radiator radiates heat into the room
toaster	**heat rays from wires cook toast**
hot asphalt	**heat and light absorbed is emitted as heat**
fox ears	**foxes that live in cold places have smaller ears so they don't radiate as much heat**

Many more examples could be given, including heat from a fire, energy coming from the sun, polar bear fur and skin, and heating elements and reflectors. A microwave oven would not be an example of radiated heat since the microwaves are not infrared waves.

Section 4: Activity 2

1. What are the best ways of preventing heat from transferring away from a sample of hot water? (You may have restated this in your own words.)

2. You should give examples of materials with low thermal conductivity, such as air, down, cork, glass, or others from table 3-1 with low values. You may also name other materials that are known to be poor conductors.

3. There must be a fluid that is being heated in one spot more than others and is free to flow in a convection current. (You will probably not include this much detail in your response.)

4. Reflective surfaces on the inside and outside of a container would inhibit radiation. Direct contact with solid matter would also inhibit radiation, especially if the material is a poor conductor.

Section 4: Follow-up Activities

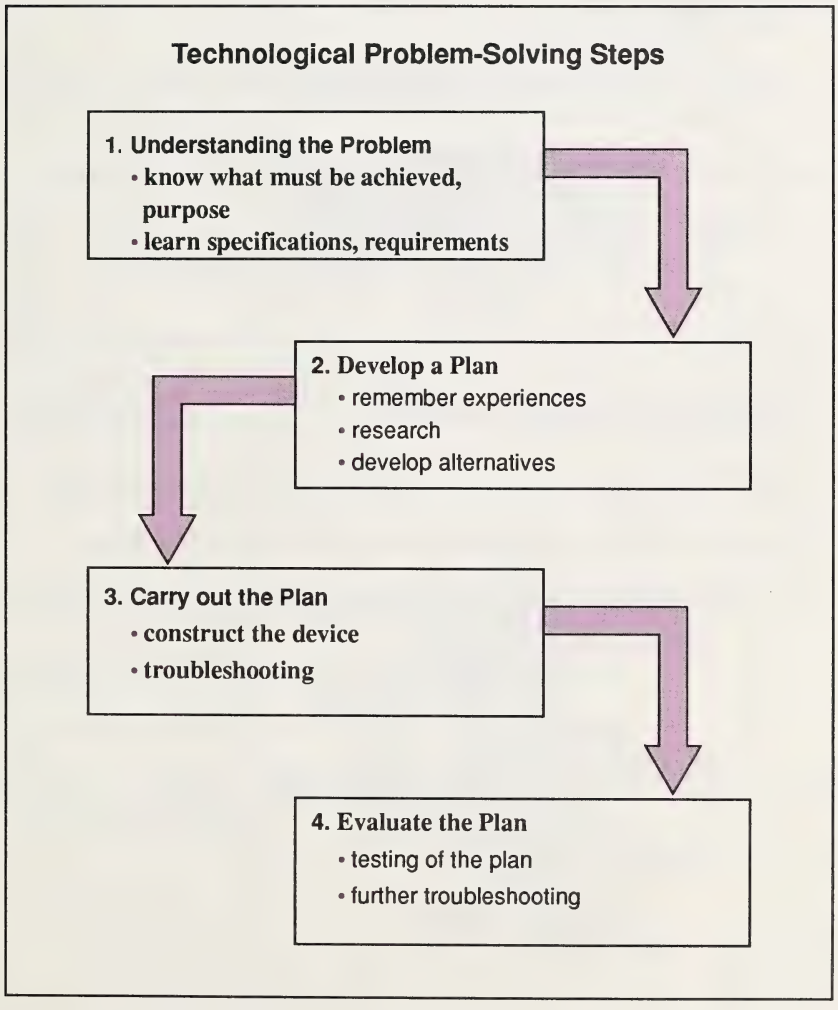
Extra Help

1. When you know how to control heat **transfer**, it is possible to make it happen more where you want it to and less where you do not. It is important for humans to **improve** their energy efficiency because the **non-renewable** resources such as oil and gas will run out one day. Trying to save these resources is called energy **conservation**.

Material that stops heat from being transferred is called **insulation**. Heat insulators can be compared using **RSI** values. This value tells us how much 1 cm of the material **resists** the transfer of heat.

The **greenhouse** effect happens because waves of light that get through the atmosphere easily are **absorbed** when they strike the earth's surface. This energy converts to **heat** and is re-emitted as infrared **radiation**. Heat that is trapped in the atmosphere by carbon dioxide and water vapour cannot **escape** into space easily. This results in a warming effect that keeps the surface temperature relatively warm, even in **winter**.

2.



Section 5: Activity 2

1. In the metric system, heat is measured in units called **joules**. The symbol for this unit is **J**. The amount of energy that it takes to change the temperature of 1 kg of a substance by 1°C is called its **specific heat capacity**.

2. The unit of specific heat capacity, stated using symbols, is **J/(kg°C)**. The specific heat capacity of water is **4200** J/kg°C. This means that it takes **4200** J of heat to cause a temperature change of **1** °C in 1 kg of water.

Section 5: Activity 3

1. The fact that energy is never created or destroyed is referred to as the Law of Conservation of Energy.

2. The heat can go into the pipes, the air, and any fixtures such as taps.

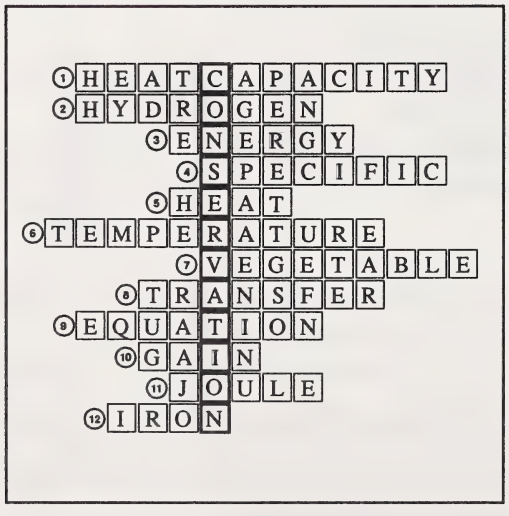
3. 60°C

4. 70°C

5. 60°C

Section 5: Follow-up Activities

Extra Help

1. 

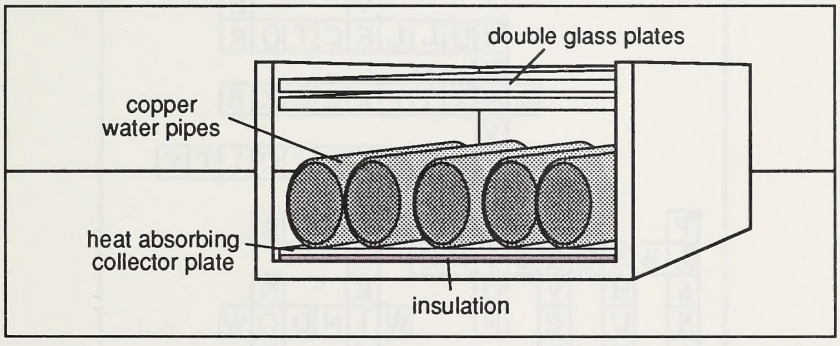
Solution: An important thing to think about when you are talking about heat is **conservation**.

Section 6: Activity 2

1. Active systems absorb and distribute the energy by carrying it to another part of the house.

2. Liquids (usually water) are used to absorb and distribute the heat in an active system. This is a good choice because liquids flow easily but do not expand very much when heated.

3. In order to catch the sun's rays, the collector must face the sun, which is found in the southern sky most of the time.

4. 

5. They allow light to pass in but trap the heat. The dead air space helps stop the heat from escaping by conduction.

6. Copper has a high thermal conductivity rating. It will absorb heat quickly.

7. The insulation helps prevent loss of heat through the bottom of the collector.

8. Convection and electric pumps circulate the liquid in an active system.

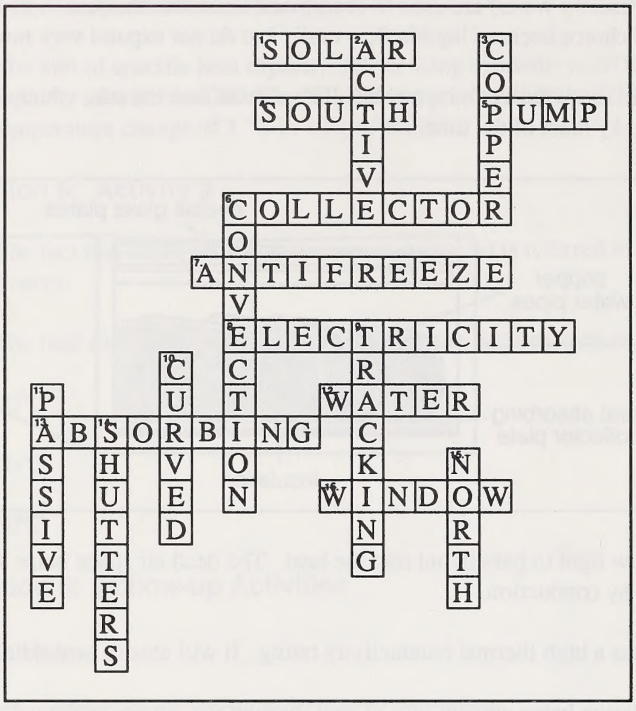
9. These collectors focus the radiation on one spot.

10. An automatic tracking system keeps the collector facing the sun.

11. Antifreeze keeps the liquid in the collector from freezing, but lowers the specific heat capacity of the liquid.

Section 6: Follow-up Activities

Extra Help



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